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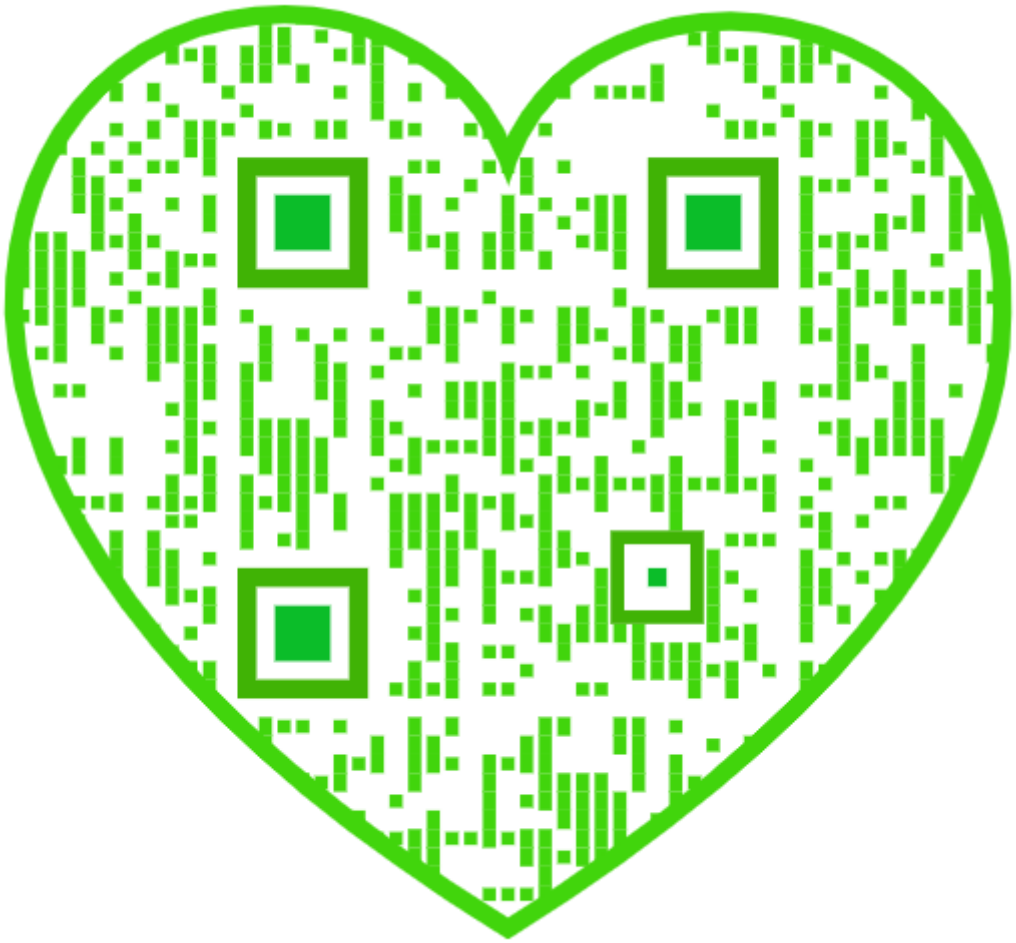

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SURGICAL

DIAGNOSIS AND TREATMENT

BY AMERICAN AUTHORS

EDITED BY

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CONTENTS.

THE SURGERY OF THE ESOPHAGUS 17
By Willy Meyer, M.D.

SURGERY OF THE BREAST 139
By Robert B. Greenough, M.D.

THORACIC SURGERY 199
By Charles A. Powers, M.D.

WOUNDS OF THE CHEST 313
By Dennis W. Crile, B.S., M.D.

SURGERY OF THE HEART AND PERICARDIUM 331
By Harry M. Sherman, A.M., M.D.

SURGERY OF THE LIVER AND GALL-BLADDER 357
By Joseph Ransohoff, M.D., F.A.C.S., F.R.C.S. (Eng.),
and
J. Louis Ransohoff, M.D., F.A.C.S.

SURGERY OF THE PANCREAS 427
By John B. Deaver, M.D., and Damon B. Pfeiffer, M.D.

SURGERY OF THE SPLEEN 501
By William J. Mayo, M.D., and Alexander Archibald, M.D.

DIAGNOSIS OF SURGICAL DISEASES OF THE STOMACH AND THE DUODENUM 559
By Frank Smithies, M.D., F.A.C.P.

SURGICAL TREATMENT OF DISEASES OF THE STOMACH 703
By J. M. T. Finney, M.D.

SURGERY OF THE DUODENUM . 763
By Albert J. Ochsner, M.D., LL.D., F.A.C.S.

CONGENITAL HYPERTROPHIC PYLORIC STENOSIS . 773
By Robert E. McKechnie, M.D.

SURGERY OF THE GREAT OMENTUM 789
By Kenneth A. J. Mackenzie, M.D.

THE SURGERY OF ILEUS 803
By Fred T. Murphy, M.D.

THE SURGERY OF THE ESOPHAGUS.[1]

By WILLY MEYER, M.D.

Until within recent years the esophagus was the only organ in the human body which was not open to surgical attack whenever thorough exposure of its thoracic portion was required. Even today there are surgeons who do not admit the justification of such interference, although the pathological condition of the esophagus may call for it.

The cause for the peculiar, exceptional position to which this portion of the esophagus was relegated—while other portions of the gastro-intestinal tract, so far as the treatment of disease was concerned, had clearly become and were generally recognized as borderline territory—was the difficulty and the immediate danger of a direct attack on it.

The difficulty was surgical and consisted in rendering the organ accessible between the apex of the pleural cavity and the diaphragm, if necessary, for this entire length; the immediate danger was physical and consisted in the required opening of one or both pleural cavities, involving unilateral or bilateral acute pneumothorax.

The introduction of the differential pressure method by Sauerbruch,[2] in 1904, has brought a final and lasting change. From his demonstration of the feasibility of overcoming the mentioned obstacle a new development of thoracic surgery took its start. Today the thorax is widely and safely open to surgical work, and we can operate within the thorax with the same ease of mind as in any other part of the body.

Gradually four useful variations of the employment of differential pressure have been evolved, from which the surgeon may select in order to avoid the dangers of the acute pneumothorax.

Through careful observation and study of patients operated upon we have further learned to appreciate the dangers which confront the patients in the course of the after-treatment, and have accordingly tried and succeeded in finding proper means to overcome them. Certainly, the reverential fear of old, to open a healthy pleural cavity accidentally, or to open it intentionally in order to get at a diseased esophagus, need no longer exist. On the other hand it is important,

[1] The manuscript of this contribution was completed in January, 1916. It was brought up to date when reading proof, March, 1920. Although no other chapter of operative surgery has benefited more by the experience of the World War than thoracic surgery, the surgery of the esophagus has remained in *statu quo*, for obvious reasons. Only by further careful investigation, observation and operating in civil life, can the fascinating surgery of the organs situated within the posterior mediastinum become gradually clarified and broadened in scope and practical possibilities.—Diseases which have no direct bearing upon operative surgery, have not been considered in this article.

[2] Centralbl. f. Chir., 1904, No. 6; Arch. f. klin. Chir., 1904, lxxiii, 977; Mitt. a. d. Grenzgeb., 1904, xiii, 399.

that the dangers connected with the occurrence of an acute pneumothorax be thoroughly recognized and appreciated.

Briefly stated, the foundation for the more universal employment of active surgery in diseases of the esophagus rests on the recognition of the necessity of using differential pressure in these operations.

After these introductory remarks we will now turn to the subject under consideration.

ANATOMY OF THE ESOPHAGUS.

The reader is familiar with the anatomy and physiology of the esophagus; nevertheless it will not be amiss to review them briefly.

The esophagus—"food carrier," literally translated from the Greek—is the connecting tube between the pharyngeal cavity and the stomach. It is about 9 inches ($22\frac{3}{4}$ cm.) in length. Its walls are continuous with those of the pharynx and closely resemble the latter in structure. It has four layers which, counting from within outward, are: mucous, submucous, muscular and fibrous.

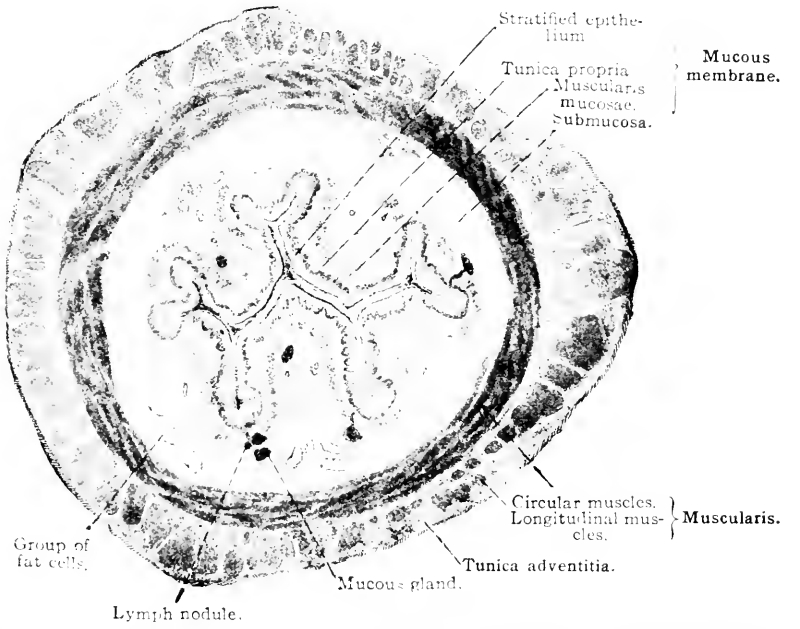


FIG. 1. Transverse section through the undistended esophagus; microscopic appearance. (Lewis and Stoehr.)

Microscopic Anatomy.—The mucous membrane which is drawn into longitudinal folds when it is not distended by the passage of food (Fig. 1) is made up of connective tissue and elastic fibers. Beneath this structure is a well-developed muscularis mucosæ, which, commencing in the lower part of the esophagus, forms a complete coat, and from

here on runs through the entire length of the gastro-intestinal tract. The thick, squamous epithelium is stratified; it resembles that of the mouth and pharynx.

The submucous membrane, composed of loosely arranged fibers and elastic tissue, contains mucous glands, the larger bloodvessels, lymphatics and nerves. The mucous glands are of two kinds, superficial and deep, and occur singly or in groups. The superficial glands are simple branched tubular and only found at the upper and lower extremity of the tube; the deep glands extend into the meshes of the muscularis and are distributed throughout the entire length of the esophagus, though most numerous in the upper third. Their epithelium is cylindrical.

The muscular coat shows an inner circular (or spiral) and an outer longitudinal layer. The fibers in the neck-part of the esophagus are striated, further down they are smooth. The change is not abrupt; the striated muscles do not suddenly disappear, but gradually become less numerous in the direction from above downward.

The outer fibrous coat (tunica adventitia) is made up of loose connective tissue, intermingled with numerous elastic fibers, and connects the esophagus with the surrounding structures. It contains many vessels and the plexiform branches of the vagus nerves which connect with the plexus between the muscle layers and in the submucosa.

Innervation.—Some nerve fibers proceed to the motor end-plates of the striated muscles, which are thus stimulated reflexly from the central nervous system; other fibers pass from the myenteric plexus to the plexus submucosus and then to the epithelium. In the latter free nerve-endings have been found. Such fibers together with those going to the smooth muscles provide local reflexes, by means of which the contents of the esophagus cause contraction above and relaxation below the place of stimulation. This action takes place independently of the central nervous system and is the form of innervation characteristic of the intestine.[1]

Topographic Anatomy.[2]—The esophagus commences at the lower border of the cricoid cartilage, opposite the sixth cervical vertebra and exactly in the median line. Extending from this point downward to the third dorsal vertebra, it is situated somewhat to the left of the trachea, a fact which has prompted surgeons to expose it at this place for external esophagotomy. Returning to the median line upon its entrance into the thoracic cavity it occupies the depth of the posterior mediastinum, hanging here perfectly free, between trachea and spinal column, for a distance of about 7 cm. ($2\frac{3}{4}$ inches) (Plate II). It then passes close to the posterior aspect of the bifurcation of the trachea and of the left bronchus (Plates I and II), which separate it from the transverse portion

[1] Lewis and Stoehr: A Text-book of Histology, 1914, 2d ed.

[2] A splendid essay on the topographic anatomy of the esophagus has recently been published by C. Hirschmann and F. Frohse (Beitr. z. klin. Chir., 1915, No. 3, Bd. xcv, p. 469) from the Surgical Division of M. Borchardt of the Rud. Virchow Krankenhaus, Berlin. It is repeatedly quoted in this paragraph and two of its illustrations are reproduced.

of the aortic arch (Plates I and II and Fig. 4). Below this point the tube turns from the right to the left of the descending aorta, crossing in front of the vessel, where it reaches the foramen esophageum of the diaphragm (Plates I and II and Figs. 3, 4 and 5). Within the foramen it is imbedded in loose connective tissue. About $2\frac{1}{2}$ cm. (= 1 inch)

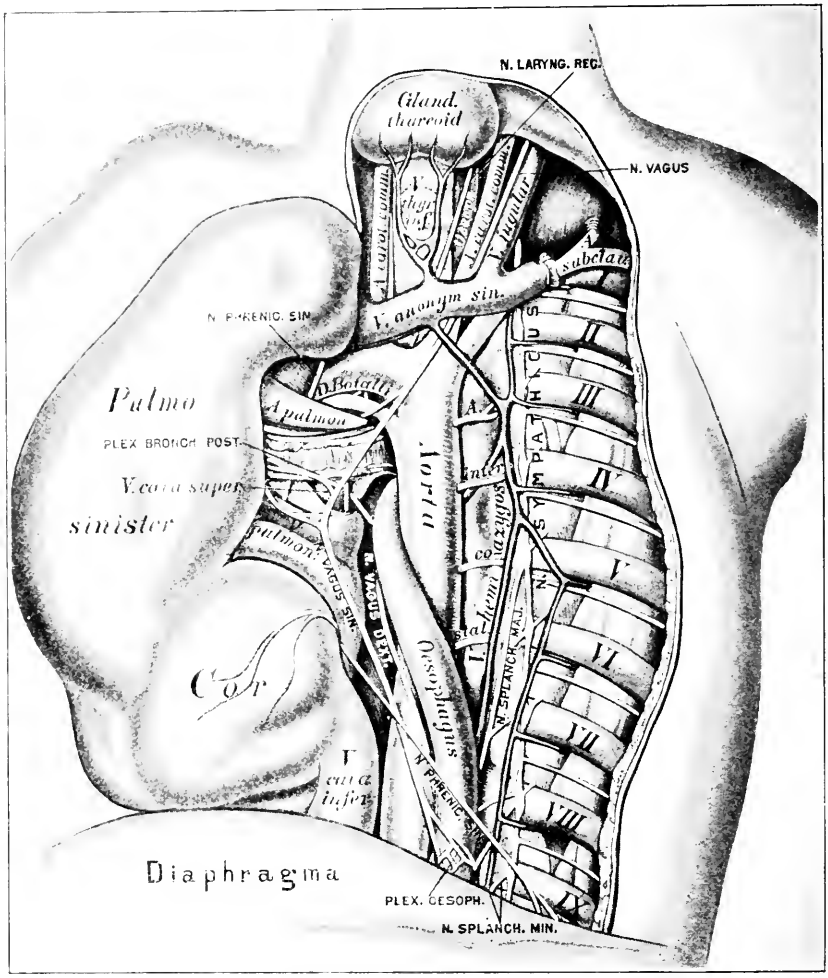


FIG. 2. Topographic anatomy of posterior mediastinum; left lung with heart turned over to the right side. The spiral made by the esophagus around the descending aorta is exaggerated in this illustration. (C. Heitzmann.)

further down it joins the stomach. Thus the esophagus curves spirally around the aorta (Fig. 2), a fact which accounts for the difficulty in swallowing in cases of aortic aneurysm; also for the fact that pointed foreign bodies within the esophagus, unless promptly removed, so easily erode the aorta. The anterior aspect of the esophagus comes

in contact with the posterior wall of the pericardium (Plates I and II and Figs. 3 and 5), and its sides are loosely covered by the right and left parietal pleura respectively, an anatomical condition which favors the perforation of the esophagus into the pericardial and pleural cavities.

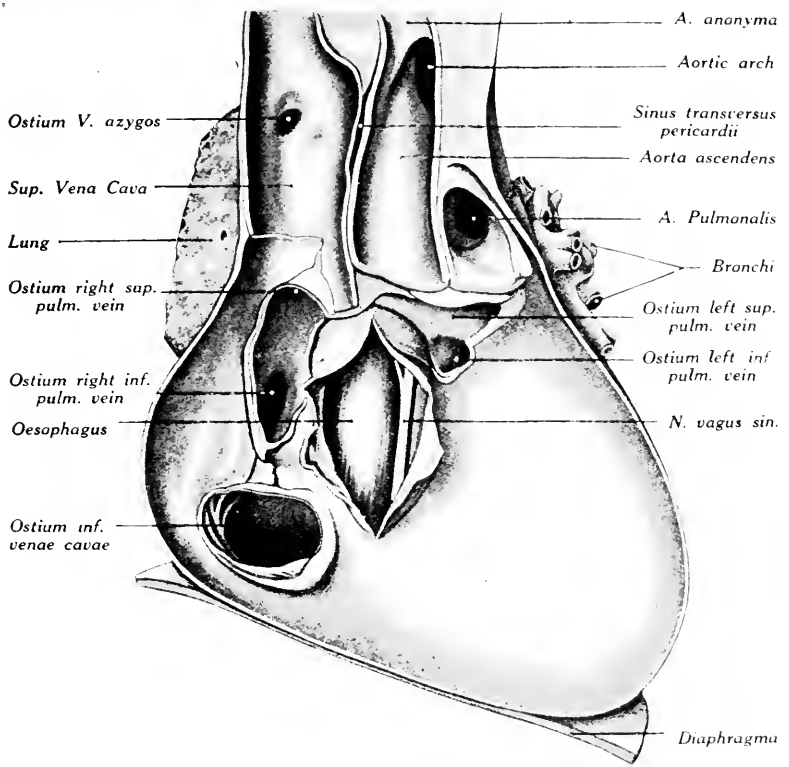


FIG. 3.—Dorsal half of a frontal cut through the pericardium with the large blood-vessels. A window has been cut out in the dorsal portion of the pericardium in order to show the esophagus. Formalin specimen. (Oskar Schultze.)

Gross Anatomy. — **Arteries.** — As topographically, so also by its blood supply is the esophagus divided into four sections: cervical; behind aortic arch; lower third; below diaphragm. The blood supply is derived: from the *inferior thyroid artery* which supplies the neck part and the upper third of the intrathoracic portion (Fig. 4); from the *posterior epibronchial artery* which is a branch of the aorta, for the portion that lies just behind and below the bifurcation of the trachea; directly from the *anterior circumference of the aorta*—arteriæ esophagei (thoracales) superiores et mediæ, and the arteria esophagei (thoracalis) inferior (Plate II and Fig. 4), vessels which are about 3 to 4 cm. long for the lower third of the intrathoracic esophagus (Plate II); from the *left superior gastric artery* (ram. esophageus abdominalis ant. et post., Fig. 6) for the abdominal portion of the esophagus. The latter branch

may be rather big, and then gains special importance in resection of the cardia.

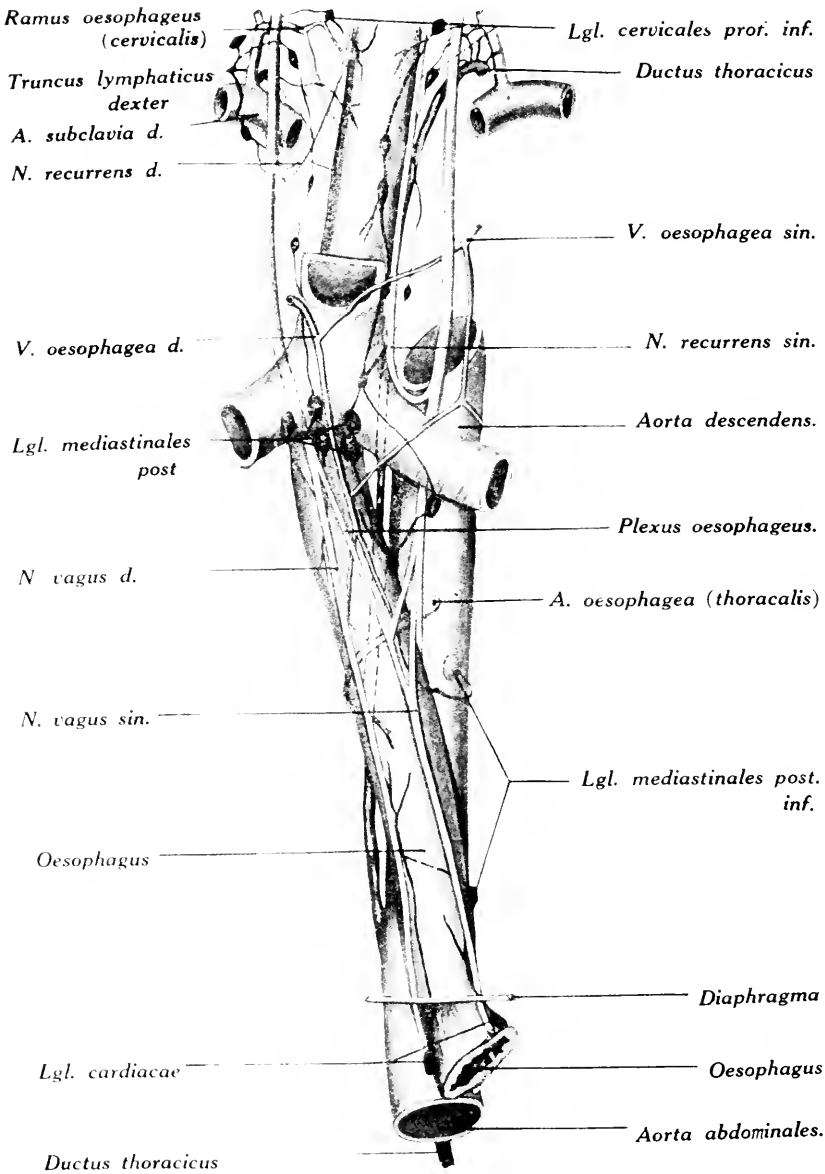


FIG. 4.—Lymphatic apparatus of the esophagus; front view, diagrammatic. (Sakata.)

All these feeding bloodvessels are pretty constant and anastomose with one another.

Veins.—The esophageal veins represent a network of wide meshes (Plate II and Fig. 4); they are loosely attached to the aorta and the

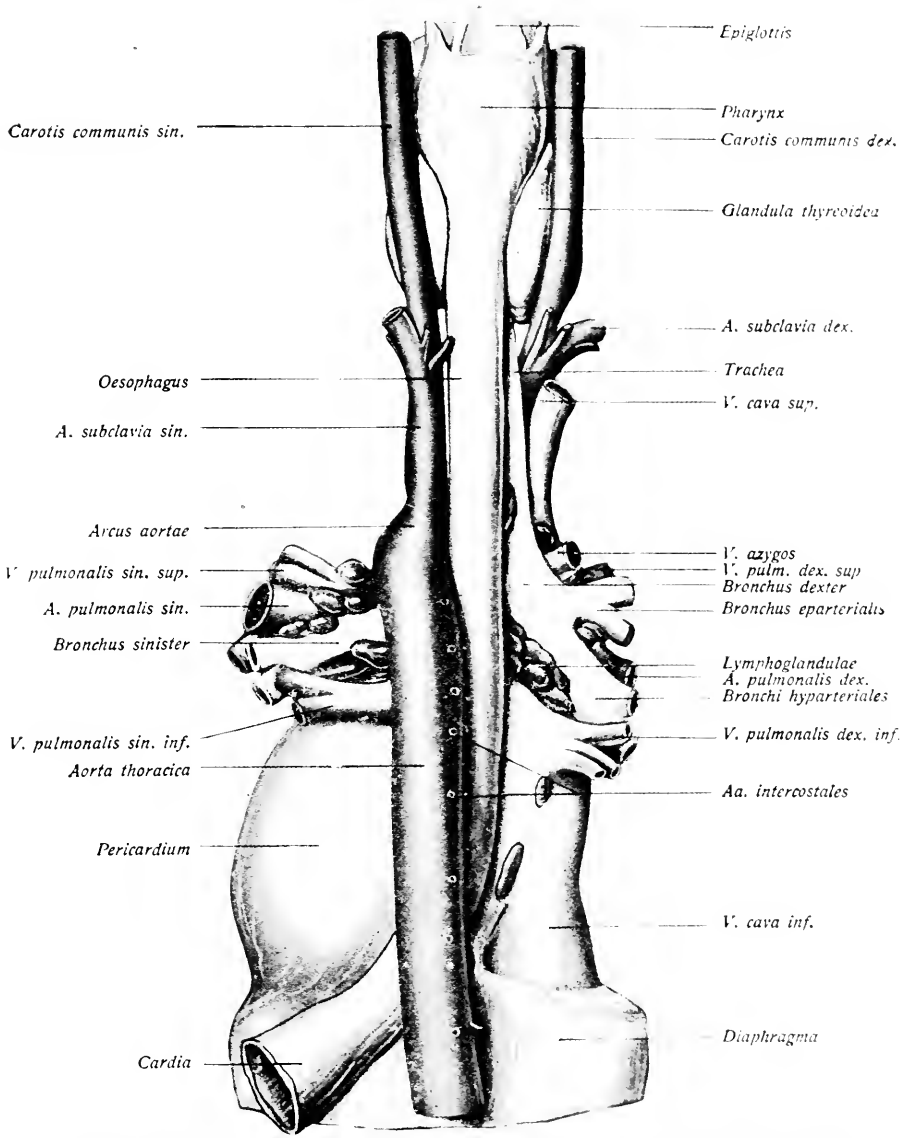


FIG. 5.—Rear view of esophagus. Note the group of lymphatic glands behind bifurcation of trachea; also the crossing of the esophagus in front of the descending aorta. (Oskar Schultze.)

anterior esophageal wall. Many anastomoses exist with the vasa vasorum of the aorta, the intercostal veins, the vena azygos and hemiazygos.

Lymphatic Vessels.—With reference to the lymphatic vessels, Sakata and Bartels[1] have demonstrated that "the lymph collecting vessels of the thoracic portion of the esophagus, one or two in number, ascend to, and empty into the deep superior and inferior cervical glands" (Fig. 4). In other words, the regional lymphatic glands, found at various levels of the neck and within the thorax, do not receive the lymph from that portion of the esophagus alone which corresponds to their level, but a large number of the lymphatic vessels of the thoracic portion of the esophagus discharge their contents into the cervical glands. This fact is of great importance with reference to regionary metastasis of esophageal carcinoma.

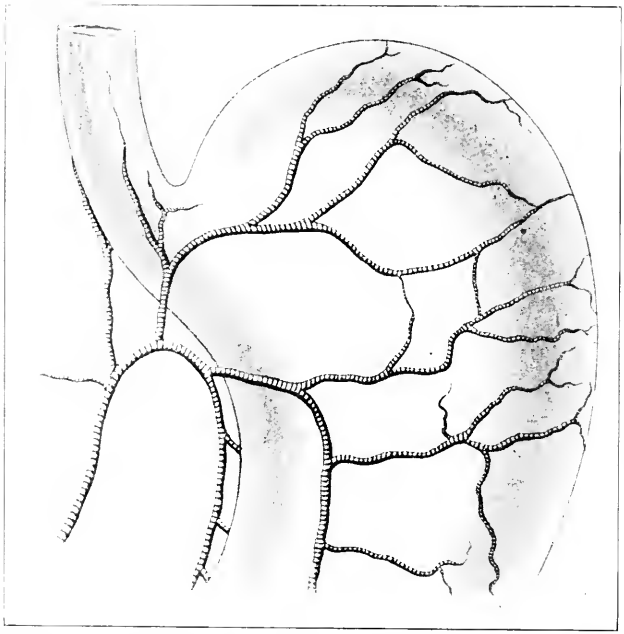


FIG. 6. Illustrating division of left coronary gastric artery. (Rio Branco.) Note the two ascending branches to the lowest portion of the esophagus, the rami esophagei anterior and posterior. They may become of importance in resection of the cardia. (Hirschmann and Frohse.)

In the lower third of the esophagus the lymphatic current is mostly downward. I have repeatedly palpated a few isolated infiltrated lymphatic glands next to the cardia as well as in the lesser and major omentum close to the cardia in cases of esophageal carcinoma involving the lower third of the tube, the cardia being macroscopically still free. Proof that the glands found were carcinomatous cannot be furnished inasmuch as they were not extirpated, but merely palpated when doing gastrostomy.

[1] Mitt. a. d. Grenzgeb., 1903, xi, 634.

Lymphatic Glands.— Fig. 4 clearly and graphically presents points of interest. There are five groups of lymphatic glands:

1. The deep superior cervical glands, at the division of the common carotid artery.

2. The deep inferior cervical glands, at the angle formed by the subclavian and internal jugular veins. (Some of these may be seen in the diagram.)

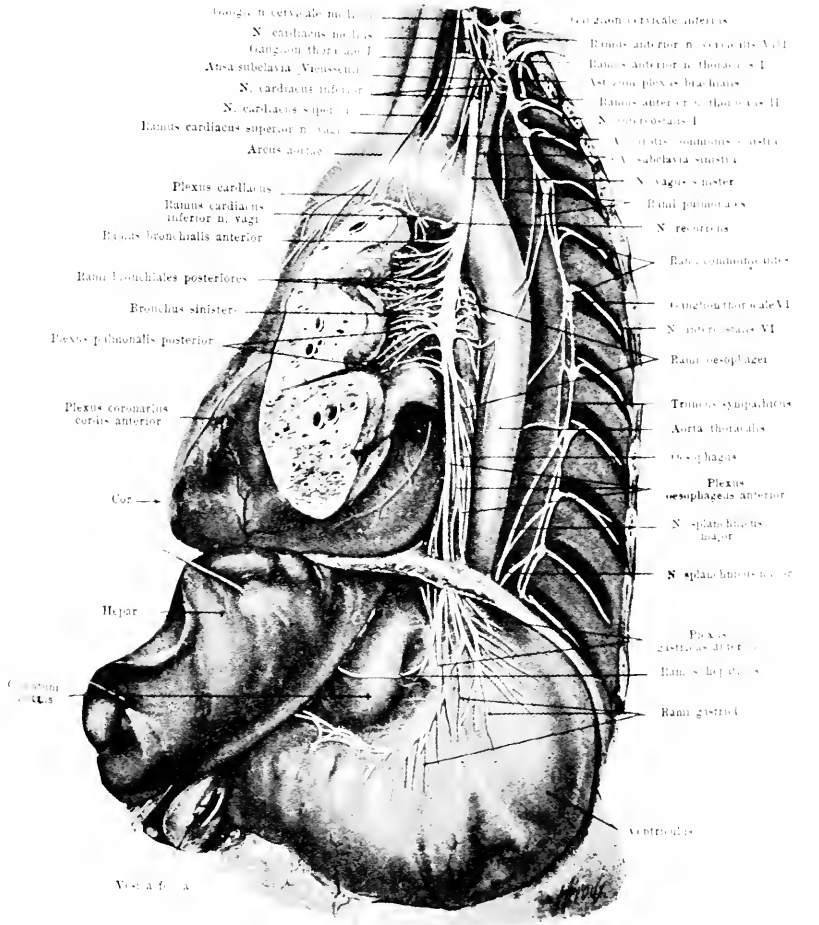


FIG. 7.—Left nervus vagus within the thoracic and abdominal cavity (view from the left). Ribs and left lung have been almost completely removed. The latter, with the liver, has been drawn to the right, the stomach to the left and downward. A part of the diaphragm has been cut away and the pleura dissected off. (Spaltholz.)

A few intermediary glands are shown near to and directly on the wall of the superior third of the esophagus; when diseased, they may be pressing upon the left recurrent nerve, causing paralysis of the same.

3. The bronchial glands, situated on the *posterior* aspect of the bifurcation of the trachea. (They cannot be seen in Fig. 4 as the bifurcation

covers them. See Fig. 5.) The greater number of the esophageal lymphatic glands is formed by

4. The posterior mediastinal glands, which are scattered around and along the thoracic aorta from the tracheal bifurcation down to the hiatus esophageus (Fig. 4).

5. Cardiac glands, two to three in number (Fig. 4).

Nerves.—The nerves of the esophagus are the two pneumogastrics or vagi (nervus vagus dexter et sinister). Their main trunks are in their superior and middle thoracic portions not in direct connection with the esophagus; branches coming from the main trunks innervate the tube (Plates I and II). The right pneumogastric is the first to join the esopha-

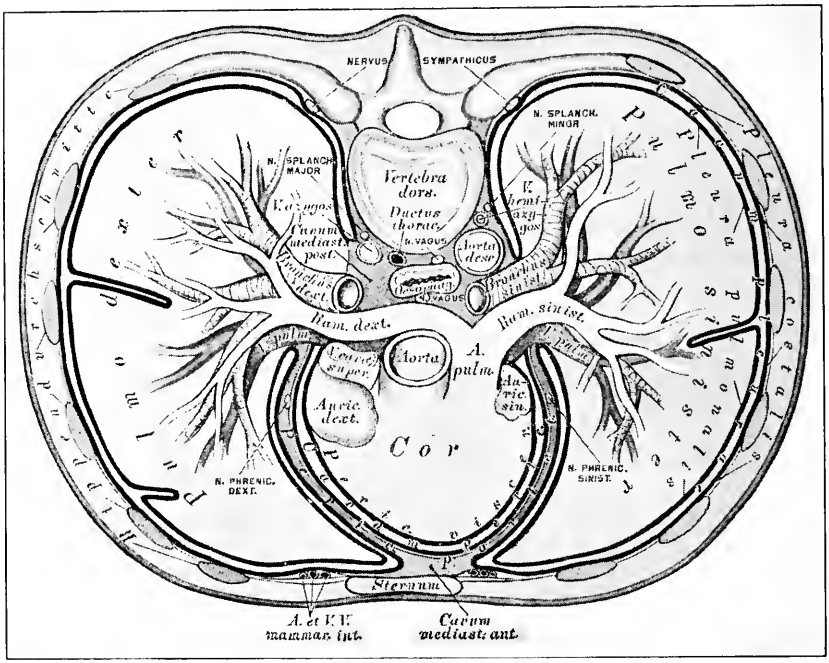


FIG. 8.—Ideal transverse section through thorax, showing the position of the contents of the thorax and the arrangement of the pleura. (C. Heitzmann.)

gus reaching it just behind the bifurcation of the trachea (Plates I and II), while the left becomes attached to it below the bifurcation, after it has passed downward in front of the aortic arch and behind the left bronchus. Here both nerves, but particularly the left, combine in forming the "esophageal plexus," which is motor and closely surrounds the tube, front and rear. Below this plexus both nerves again present separate bundles, before they enter into and pass with the esophagus through the foramen esophageum of the diaphragm. The right is situated further back than the left and innervates the posterior wall of the stomach, while the left can be seen more to the front, dividing upon the anterior gastric wall (Fig. 7). This anatomically shifted position

of the nerves is explained by the turn of the stomach during embryological development with its left portion forward, while the right portion, and with it the right pneumogastric nerve, turns backward.

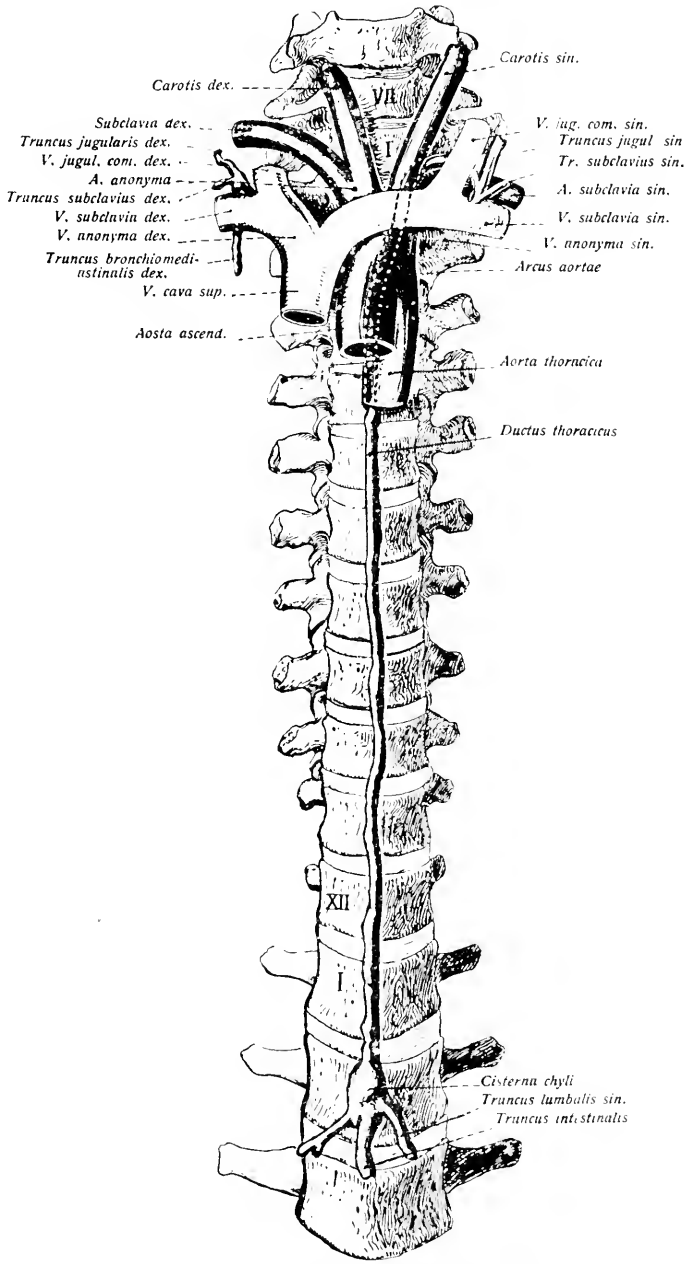


FIG. 9.—Thoracic duct. (Oscar Schultze, Topographic Anatomy.)

Thoracic Duct, Vena Azygos and Hemiazygos, and Sympathetic Nerves.—Just above the diaphragm the thoracic duct and the vena azygos run alongside the right border of the esophagus in front of the spinal column (Fig. 8). The thoracic duct, within loose connective tissue, runs exactly in the median line, straight upward (Fig. 9); above the aortic arch it is found on the left side of the esophagus (Fig. 4) and continues so to its entrance into the left subclavian vein, on the posterior aspect of the latter's junction with the internal jugular vein.

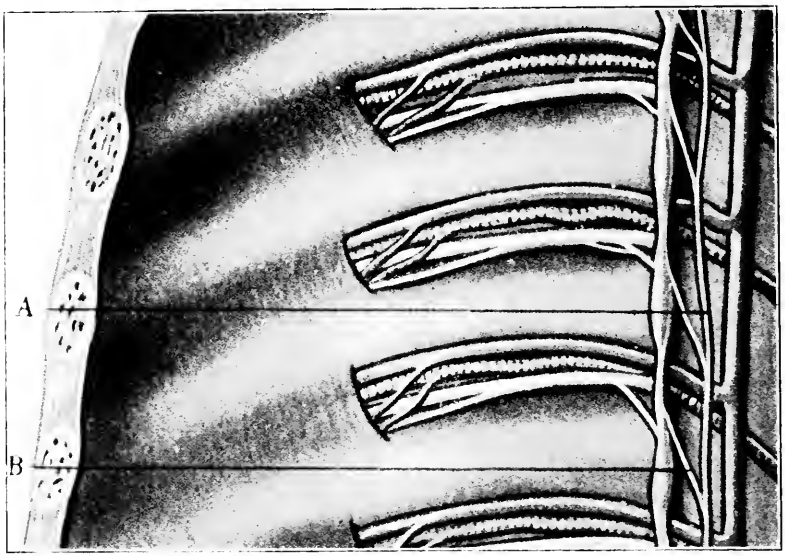


FIG. 10.—Showing anastomosis between the intercostal nerves and the thoracic portion of the N. sympathicus and its ganglia. *A*, great splanchnic; *B*, lesser splanchnic. (C. Heitzmann, "Handatlas.")

The course of the vena azygos also takes an upward direction. The vessel passes along the anterior aspect of the dorsal vertebrae to the right of the thoracic duct (Plate II). This part is called "the ascending portion of the vena azygos." On its way it receives the right intercostal veins and a communicating branch of the vena hemiazygos (Plate II and Fig. 2). The latter usually joins it at the level of the seventh or eighth dorsal vertebra. The vena azygos then passes behind the right bronchus (Plate II). At the upper border of the latter the venous plexus of the esophagus discharges its blood into it (Plate II); another tributary is a larger vein, running from above downward, called the descending portion of the vena azygos (Plate II). The main trunk of the vein then crosses the right bronchus (Plate II and Fig. 5) and empties into the superior vena cava (Fig. 5).

The vena hemiazygos runs along the left side of the spinal column (Fig. 2). It represents the continuation of the left lumbar venous plexus, the same as the vena azygos forms the continuation of the right

lumbar venous plexus. It collects the blood from all the twelve left intercostal veins: those from the lower five ribs empty into it directly and separately; those from the first to the seventh discharge into the superior hemiazygos vein, which joins the lower trunk before it crosses the body of the seventh or eighth dorsal vertebra. There are many variations.

Sympathetic Nerves.—The thoracic portion of the sympathetic nerves is situated outside of the posterior mediastinum, in front of the capitulum of the ribs (Figs. 2, 7, and 10) and is covered by the costal pleura. The eleven thoracic ganglia of the sympathetic nerves are connected by two nerves, which also communicate with the respective intercostal nerves.

There are four plexuses: cardiac, aortic, pulmonary and esophageal. The esophageal and pulmonary plexuses are in closest relationship to the plexuses of the two pneumogastrics. Fibers of the latter are also nourished by the cardiac and aortic plexuses and the superior thoracic ganglia (Fig. 7).

PHYSIOLOGICAL POINTS OF THE ESOPHAGUS.

Physiologically the esophagus has four places of stricture (Fig. 11):

1. At its very beginning, behind the cricoid cartilage at the neck, *i. e.*, a distance of about 15 cm. (6 inches) from the incisor teeth (Figs. 12 and 13). The diameter here is 14 mm. ($= \frac{9}{16}$ inch). Through contraction of the inferior constrictor pharyngis muscle, the introduction of sounds may be rendered difficult to a certain degree at this point.

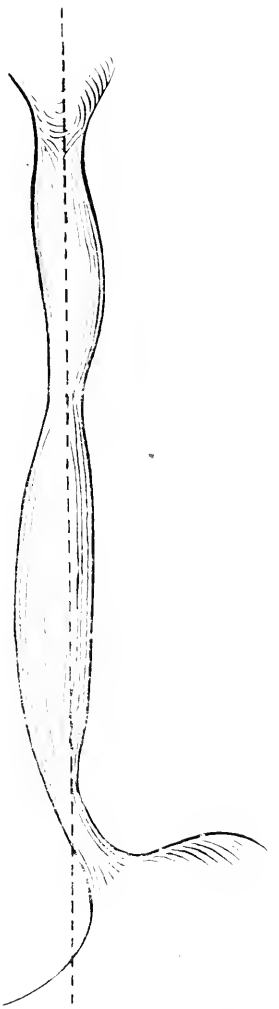


FIG. 11.—Front view of esophagus with the physiological strictures and dilatations. Dotted line represents median line. (Corning's Topographic Anatomy.)

2. Behind the bifurcation of the trachea, due particularly to the many lymph nodes (bronchial glands) (Fig. 5), which are here situated in front of the esophagus and the crossing of the esophagus and the aortic arch. The distance from the teeth to this stricture is about 25 cm. (10 inches).

3. At the hiatus esophageus of the diaphragm, about 40 cm. (16 inches) from the teeth, where the diameter is again 14 mm.

4. At the cardia, about 2 cm. farther down, 42 cm. ($16\frac{1}{2}$ inches) from the teeth.

These are but average figures; the distances vary greatly in different individuals. They are shorter in females than in males.

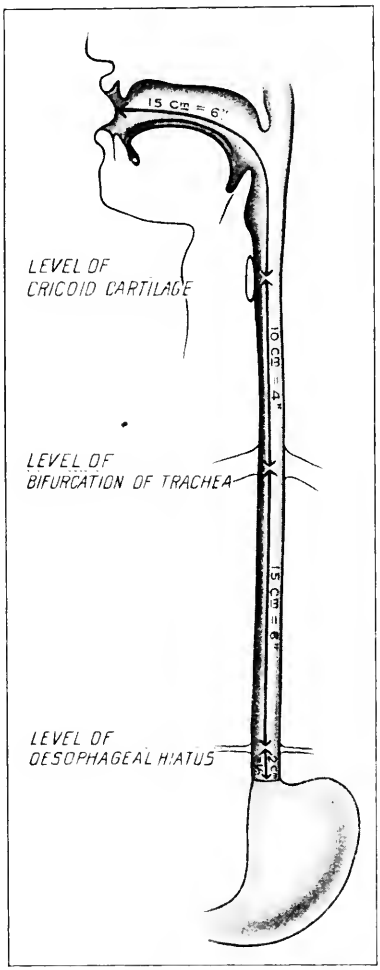


Fig. 12.—Diagram showing distances up to and between the physiological strictures of the esophagus.

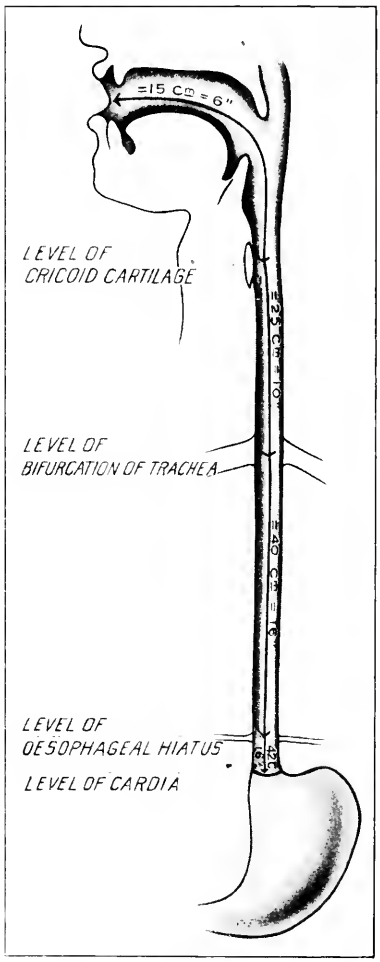


Fig. 13.—Diagram showing distances from the incisor teeth to the physiological strictures of the esophagus.

It will be seen from these figures that the distance from the incisor teeth to the beginning of the esophagus and the distance from the tracheal bifurcation to the cardia are of almost equal length, about 15 cm. (6 inches) each, and that the first portion of the esophagus from the cricoid cartilage to the bifurcation of the trachea measures about 10 cm. (4 inches) (Fig. 12).

EXAMINATION OF THE ESOPHAGUS.

As regards examining the esophagus, recent developments have added greatly to our facilities for that purpose and have placed us in a position to diagnose its pathological conditions. We shall take into consideration

I. The Older Methods of Examination.—Sounding.—As in other canals of the body, sounding is done for the purpose of locating and dilating strictures.

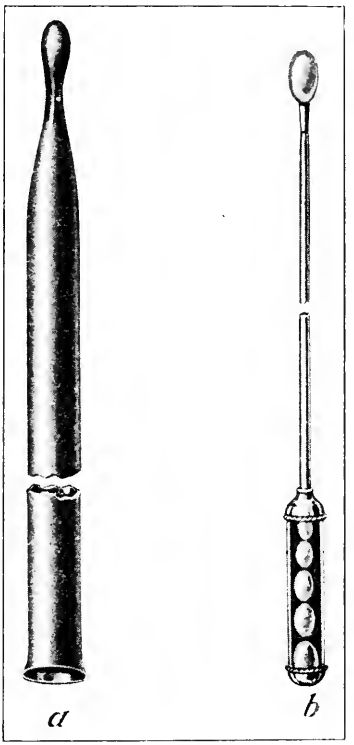


FIG. 14.—*a*, conical esophageal silk-webbed bougie; *b*, olive-tipped metal (or hard rubber) bougie; exchangeable tips of various sizes stored in handle with screw cap.

(*a*) *Posture of the Patient.*—It is best to have the patient seated; his clothes properly protected by some kind of cover, preferably impermeable, a basin in his hand to catch saliva or stomach contents. Tooth plates must be removed. By bending the head slightly forward the entrance into the esophagus is opened. The majority of patients are inclined to sit back in the chair and raise the head as far as possible, looking at the ceiling. That is wrong, as in this posture the contents of the mouth will flow back toward the larynx and produce coughing.

(*b*) *Instruments.*—The olive-tipped bougies, metal or hard rubber, with four or five different sized olives that can be securely screwed on to the bougie, and the silk-webbed bougies, with conical points (Fig. 14),

should be at hand. The first variety of instruments is used for diagnostic purposes; the latter for treatment.

Recent years have brought us useful additions, viz., Callman's esophageal sound, with mushroom tip[1] and Schreiber's esophageal sound for retrograde exploration.[2] Both are useful for establishing "an early diagnosis." They are deserving of a definite place in our instrumentarium.

Callman's sound, originally designed for examination of the rectum, consists of a steel rod and several sizes of mushroom tips, the sizes varying from 15 to 36 French gauge, and the difference in diameter between sizes being 3 mm. each (Fig. 15*a*). On passing a tip of proper size through the normal esophagus, the fingers, gently guiding the sound, have the sensation of passing over a soft, smooth and elastic surface. The mucous membrane closes in upon the head of the sound and thus is palpated. Wherever the tissue has changed, the surface is felt to be uneven. The instrument is especially advised for use in nervous patients, in whom it is difficult to distinguish between spastic and neoplastic stenosis; further, when an organic stenosis is accompanied by spasm of the muscularis, the symptoms of the latter overshadowing those of the former; finally, in the initial stages of cancer, before the stricture has fully developed. As regards the cardia, it should be noted that the sound passes it in the healthy state frequently with a jerk.

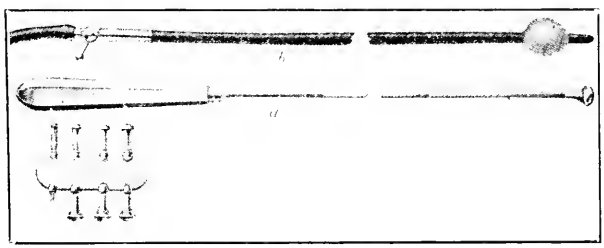


FIG. 15.—*a*, Callman's sound with a set of mushroom tips; *b*, Schreiber's sound designed for retrograde exploration.

Schreiber's sound is constructed for retrograde exploration. It gives reliable information of a stenosis which it would be difficult to detect with an ordinary sound. It is a rubber sound to which a small soft rubber bulb is attached (Fig. 15*b*). After introduction into the stomach, water is filled into the bulb; thus distended the sound is slowly pulled upward and moves along smoothly where the esophagus is normal, but is arrested, where it is diseased. Such spots hold the sound so tightly that even quite a strong pull will not dislodge it.

(*c*) *Method of Introduction.*—The examiner sits or stands in front of the patient. The instruments are dipped in water or made slippery

[1] Callmann, R.: Deutsch. med. Wchnschr., 1911, p. 497.

[2] Schreiber, J.: Berl. klin. Wchnschr., 1911, No. 25. See also Willy Meyer, Surg., Gyn. and Obstet., Dec. 1913, p. 693.

with some lubricant, a jelly preferably. Olive oil, vaselin and glycerin are objectionable to many patients. The tip of the left finger is placed upon the back of the patient's tongue and presses it gently forward. The right hand introduces the sound either in the median line or somewhat to the left of it. Contact with the buccal mucosa should be avoided, as it produces gagging. In very sensitive patients, particularly those with pronounced reflexes, a brief spraying or touching-up with cocain (10 per cent.) may be of great benefit. Local analgesia is not required. The patient is told to swallow, and with that the tip of the instrument enters the esophagus. The physiological strictures often offer slight resistance to the downward passage of the bougie, particularly the first one behind the cricoid cartilage. Most gentle handling of the sound is imperative during the entire manipulation, on introduction as well as on withdrawal. All force must be absolutely avoided.

The tip of the instrument may perforate the wall of the tube by rough handling.

Gagging, following the introduction, is often overcome by quick, deep breathing.

Auscultation.—Under normal conditions, both solid as well as liquid food is pushed forcibly through the pharynx and esophagus in the act of deglutition. That is due to the strong contraction of the muscles which close the oral cavity, particularly the mylohyoids. This phenomenon produces two sounds: the so-called "deglutition sounds," first described by Meltzer and Kronecker in 1883. The "first deglutition sound" is at times heard simultaneously with the act of swallowing on auscultating at the ensiform process. It is produced by the fluid being "spurted" down the tube—"Durchspritzgeräusch." Often this sound is not perceptible. The second sound is more frequently noted, occurring about seven seconds after the act of deglutition. It is produced at the end of the act of swallowing, by the peristaltic contraction of the esophagus, which pushes the food into the stomach—"Durchpressgeräusch." It is a râle-sound, dependent on the amount of air that travels downward with the contents of the esophagus.

The presence of these deglutition sounds permits us to judge, to some degree, of the permeability of the cardia. If both are absent, especially the second one, we are justified in assuming that the ingested mass has not entered the stomach but is retained in the esophagus above the cardia. This is most often the case in strictures (cancer), although, occasionally, this condition might be caused by a deficiency in the peristaltic movement of the esophagus.

II. The Newer Methods of Examination.—**Esophagoscopy.** The advent of the electric mignon-lamp and its adaptation to the requirements of endoscopic examination as well as of operative surgery within a canal that can be entered from the surface of the body has wrought the same advance for the esophagus as for the bladder and ureters, the rectum, bronchi, etc. It aids the diagnosis by permitting (1) direct visual inspection, (2) the punching out of projecting tumor masses,

(3) the scraping of an ulceration for microscopic examination. It is also of great value in the bloodless extraction of foreign bodies that were swallowed and became stuck in the esophagus, also in the stretch-

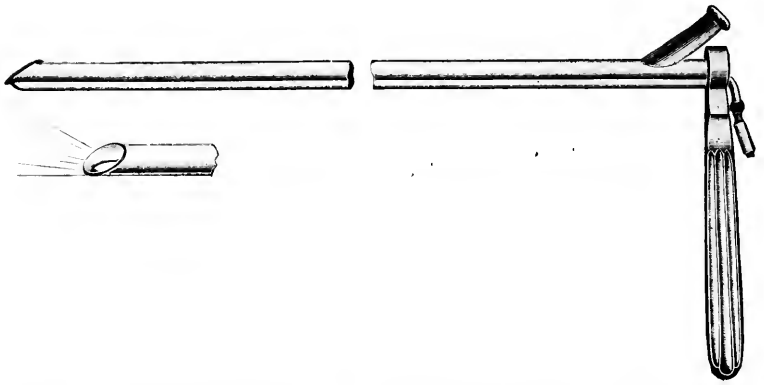


FIG. 16.—Jackson's esophagoscope with slanted end, facilitating introduction of the instrument. (Jackson.)

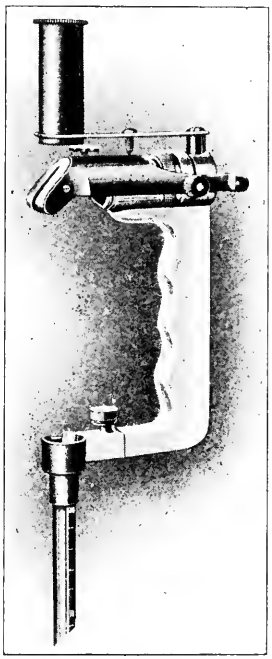


FIG. 17. Brüning's illuminating handle for the esophagoscope.

ing of strictures under the guidance of the eye, etc. Esophagoscopy, within the last fifteen to twenty years, has gradually developed into a specialty. Today every hospital should have its official esophagoscopist, with the same right and on the basis of the same necessity

that calls for a cystoscopist, radiologist, etc. Needless to say that the esophagoscopist should be so thoroughly trained that no harm can by any possibility befall patients through his examination. The colleagues who call on him for assistance and entrust to him their patients for examination must be able to feel absolute confidence and assurance as regards this point.

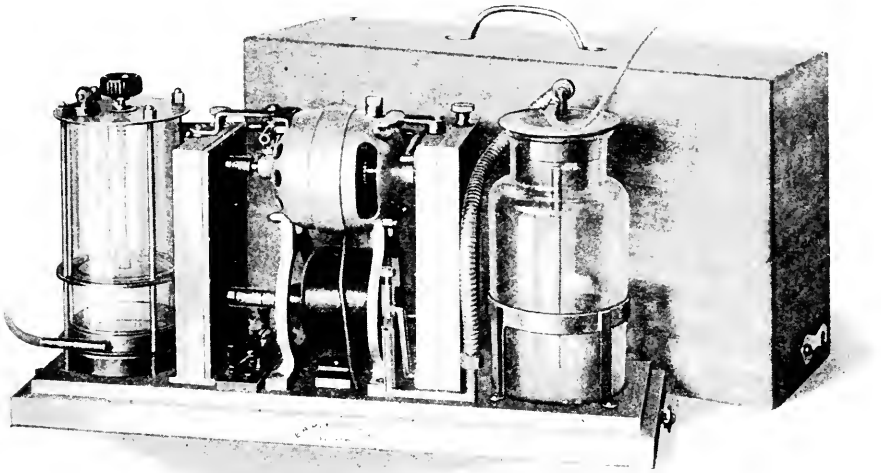


Fig. 18.—Yankauer's electric suction apparatus.

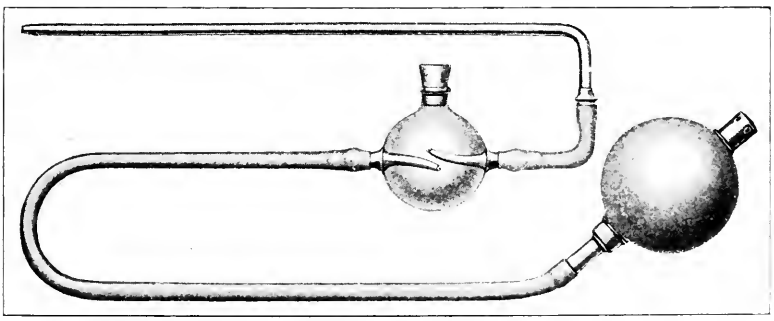


Fig. 19.—Brüning's saliva aspirator.

The instrumentarium has become standardized. Jackson's (Fig. 16) and Brüning's (Fig. 17) esophagoscopes are particularly favored. The electric suction apparatus (Fig. 18) is an indispensable addition. There are several good ones in the market today. Those driven by electricity appear to be more practical than Brüning's, which an assistant works by hand with a rubber suction bulb (Fig. 19).

The examination can usually be done under local cocain (10 per cent.)

anesthesia, although the patients should always be prepared for general anesthesia. The horizontal posture appears preferable, the head hanging backward from the table (Rose's posture). The patient's neck is supported by the arm of an assistant, whose hand at the same time takes hold of the mouth-gag, which had been put in place. The esophagoscope, without obstructing mandrin, is gradually pushed forward into the tube, same as we proceed in urethroscopy, rectoscopy, etc. In this way nothing abnormal will escape the inspecting eye.

These brief remarks have to suffice with reference to esophagoscopy. Those more particularly interested in this branch of endoscopic diagnosis and therapy are referred to the huge literature on the subject that has accumulated within the last two decades.

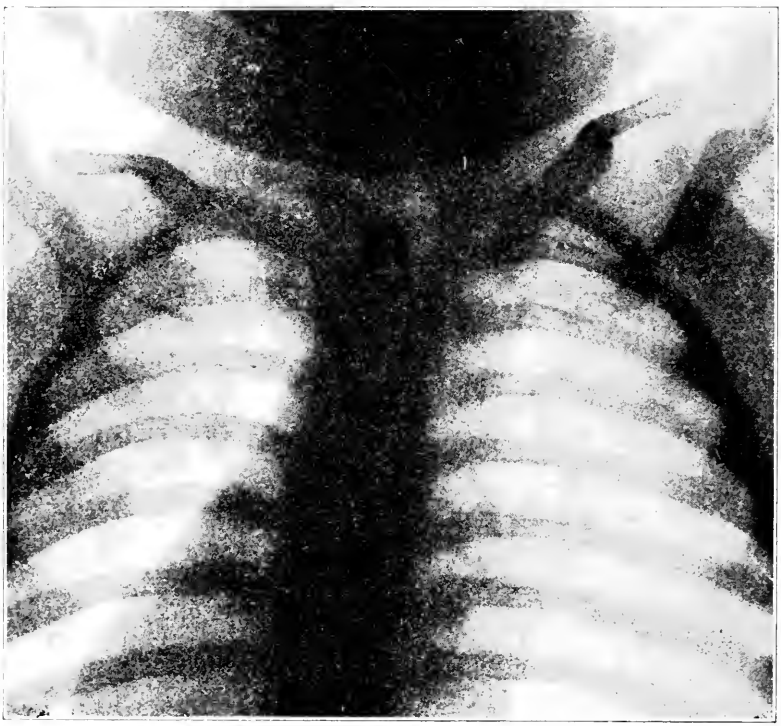


FIG. 20.—Open safety pin in the esophagus.

Radiography and Fluoroscopy.—The *x*-rays have immensely added to a clearer understanding and diagnosis of esophageal diseases. Their value cannot possibly be overestimated. Especially does the stereoscopic radiogram often furnish a wonderful amount of information. It affords genuine "scientific" pleasure to view such a picture with its plastic details. The radiogram will show and locate most of the foreign bodies (Fig. 20); it will show the swallowed and partially arrested bismuth-paste and the scant amount of it that could be pressed

through the stenosed portion (Fig. 21); it will reveal the presence, location and extent of a stricture and the dilatation of the tube above (Fig. 22); and it will demonstrate whether the walls of the esophagus are smooth or irregular. The endeavors of radiographists have lately aimed even still higher: they have tried to make possible, by means of the *x*-rays, the *early diagnosis* of the trouble which, after a while, will inevitably lead to a stenosis (carcinoma); and there is no reason why, with further patience and perseverance, they should not succeed. A sausage-skin (hog-casing), tied at its lower end, is either carried on a mandrin through the stricture, or else it passes the stricture

FIG. 21.—Congenital stricture of esophagus, boy aged fifteen years; personal observation. This instructive negative was taken by Dr. W. H. Stewart, radiologist to the Lenox Hill Hospital of New York.

by being swallowed in a collapsed condition by the patient. Thereupon it is filled with bismuth solution by means of a syringe or a salvarsan irrigator (Hessel, Armistead C. Crump, W. H. Stewart). Its shadow will then demonstrate on the *x*-ray plate, whether the walls of the tube are rough, and hence suspicious of local infiltration, or smooth. Fig. 23 illustrates Dr. Crump's instrumentarium for this purpose; it has been greatly improved within the past two years and will soon be published. (Personal Communication.) Inspection of the plates with proper lenses will render a correct interpretation of the radiogram easier and more definite. Much is to be expected from these recent experi-

ments for an early diagnosis of carcinoma, a matter so absolutely, so seriously needed for a more rapid improvement of operative results in this chapter.

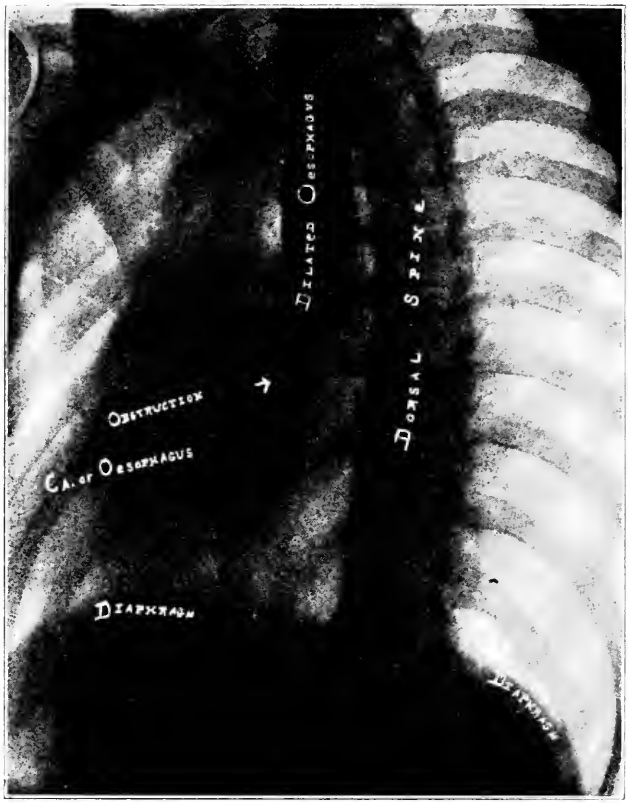


FIG. 22.—Stricture of the esophagus due to a carcinoma in its middle third.

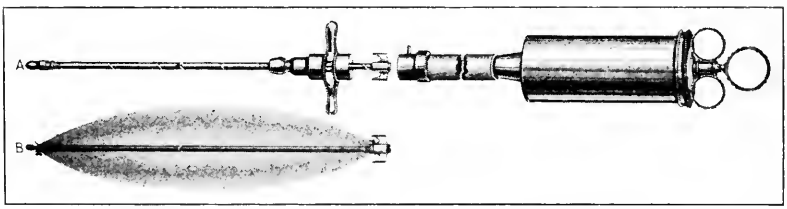


FIG. 23.—Crump's stilette for injecting with bismuth solution a hog-casing which surrounds the stilette and is fastened thereto at both ends. Useful for early diagnosis of cancer of the esophagus. *A*, stilette with spiral opening, permitting the escape of the solution at any place for inflation of the hog-casing; *B*, the latter distended, exit of the bismuth solution at the lower pole of the instrument only, for deflation of the hog-casing. (Courtesy of Dr. Crump of New York City.)

That additional thorough examination of the patient, at the hands of a trained radiographist, in front of the fluorescent screen, is an indis-

pensable procedure, and represents a most important addition to diagnostic resources and capabilities, hardly needs emphasis in a surgical text-book at this late day.

Regarding the sequence of the various examinations to be made, one may best proceed as follows:

1. *In Cases in Which the Symptoms of Stricture are Clearly Developed.*—History of the case: general clinical examination with observation of deglutition sounds; usual laboratory tests of urine and blood, inclusive of a Wassermann test; radiography. If an aortic aneurysm of the arch or of the descending portion of the aorta can be excluded: sounding, or immediate esophagoscopy. As the tubes used for the latter examination have a centimeter-scale engraved on them, they permit of measuring the distance from incisor teeth to stricture.

2. *Early Cases.*—It may be advisable, after the preliminary clinical and laboratory examinations have been completed, first to make gentle use of Callmann's or Schreiber's sound, in order to find out where the stricture in the lumen of the esophagus is located; then to do esophagoscopy and follow this up by radiography. A trained eye will readily recognize through the esophagoscope any changes in the appearance of the mucosa. The distance from the teeth having been measured and compared with the result of sounding, the radiographist will then know just how far to introduce the casing that is to be filled with bismuth or barium preparation. (See above, under "Radiography.")

The foregoing represents a brief outline of the great advance that has been made in recent years as regards the possibility of rendering a more refined diagnosis in the pathology of the esophagus. The indications are that much more may be looked for in the near future.

SURGICAL PATHOLOGY OF THE ESOPHAGUS.

I. Foreign Bodies in the Esophagus.

Foreign bodies often slip accidentally into the esophagus, and by reason of size or shape or sharp points become lodged therein. Usually they are arrested in their downward course at the physiologically narrow places of the thoracic part of the tube, viz., behind the aortic arch and above the cardia.

Frequently these arrested foreign bodies can still be made to pass down into the stomach—much to the delight of the frightened individual—by having him swallow crusts of bread or potatoes immediately after the accident. But if, in times past, the sensation of the presence of a foreign body persisted, "blind" methods of search and treatment had to be resorted to. Then extraction was attempted either by means of forceps (Fig. 24) or by specially designed instruments: brush, coin-catcher, etc. (Fig. 24), or else the foreign body was pushed into the stomach. Frequently this would happen unintentionally. In unfortunate cases, however, the obstacle was driven further into, and not infrequently through the esophageal wall, causing septic peri-

esophagitis (acute posterior mediastinitis) and death. If the foreign body was known to be large and irregular, *e. g.*, a plate of artificial teeth, external esophagotomy was performed, by means of which the body was often reached and successfully extracted.

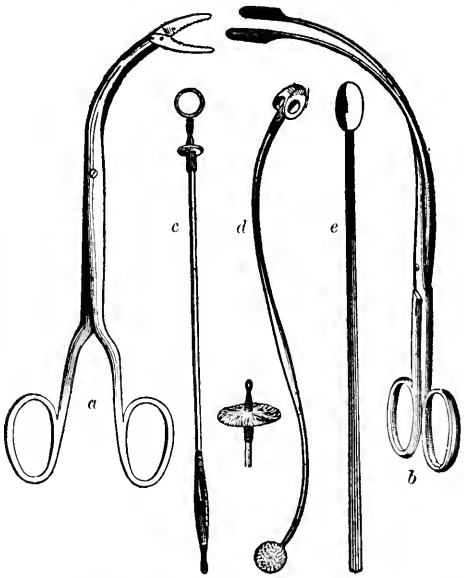


FIG. 24. Esophageal instruments. *a*, *b*, forceps; *c*, horsehair probang; *d*, coin-catcher; *e*, esophageal bougie. (Keen.)

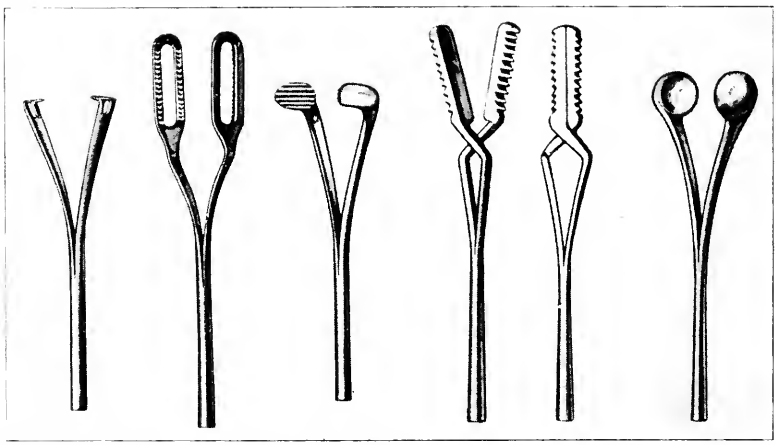


FIG. 25.—Attachments to Brüning's forceps for the endoscopic extraction of foreign bodies from the esophagus.

Today these "blind" methods have been discarded. Following radiography, esophagoscopy is promptly carried out and ingeniously constructed instruments are put in use in order to insure endoscopic extraction (Fig. 25).

Of course, even the most expert esophagoscopist will not succeed in extracting every impacted foreign body, or rather, may consider it wise to abstain from trying, in certain complicated cases. An attempt to bring the foreign body to light through an external esophagotomy wound may be equally unsuccessful, or may, in view of the esophagoscopist's findings also be inadvisable. In that event a direct operative attack upon the obstructing body is indicated.

In order to avoid the complication of an acute pneumothorax and possible infection of the pleural cavity, attempts have been made to reach the esophagus through a posterior, extra-pleural mediastinotomy (methods of Nassilow, Quénu and Hartmann, Bryant, Rehn, Enderlen).

Nassilow (Experimental).[1]—Left-side musculocutaneous flap; resection of third to sixth rib near to the spine, when penetrating to the upper portion of the mediastinum; or of a number of lower ribs for the low operation. Blunt dissection of pleura, until the organs of the mediastinum are exposed.

Quénu and Hartmann (Experimental).—They made an incision, 15 cm. in length, along the angle of the ribs, its middle corresponding to the level of the scapular spine, resected the third, fourth and fifth rib, about one inch of each, and pushed the parietal pleura off bluntly. That done, they advanced a hand into the posterior mediastinum and exposed to view the hilus of the lung, the aorta and the esophagus from the bronchus down to the diaphragm. Although the esophagus is here situated more toward the right of the spinal column, the authors advise entering the posterior mediastinum on the left side, owing to the anatomical conditions. On the right side the pleura passes between the posterior aspect of the esophagus and the spinal column in the shape of a deep fold which extends from right to left well beyond the median line on to the left. On the left side the parietal pleura passes in a continuous straight sweep over the anterior surface of the posterior mediastinum, making access easier.

Bryant[2] forms a rectangular flap of soft tissues with base over the spinous process of the three vertebræ that correspond to the level of the arrested foreign body. Above the aortic arch the flap is made on the right or the left side; below the aortic arch, on the right side. The rib in the middle of the flap is resected, the one adjacent above and below temporarily resected and the pleura carefully loosened. A sound is introduced into the esophagus which marks the seat of the foreign body; thereupon longitudinal incision of esophagus; removal of foreign body; tamponade of esophagus; drainage and fastening of flap by suture.

L. Rehn[3] forms the same skin-muscle flap as in Bryant's operation, but makes it longer, placing the base over the spinous processes of the third to ninth dorsal vertebræ. He proceeds with a longitudinal incision at the border of the scapula, followed by wide resection of seven ribs in the exposed area and careful separation of the pleura.

[1] Nassilow, J. J.: Referred to in W. Levy, Arch. f. klin. Chir., 1898, Bd. lvi.
[2] Trans. Am. Surg. Assn., 1895.
[3] Verhandl. d. deutsch. Gesellsch. f. Chirurgie, 1898, vol. xxvii.

Enderlen's[1] operation is similar to Rehn's. He points out the fact that the skin-muscle-bone flap can be nicely and safely formed by first exposing the eighth rib in its periosteal envelope for a distance of 10 cm. (4 inches); then dividing it and pushing off the pleura (see Fig. 56 on page 89). From here the next rib above is easily reached, again the pleura pushed off and the rib divided, and so on, up to the fourth. Thus a large flap of bone and muscle is formed. Inasmuch as the preservation of the divided ribs with the soft parts is of no special importance, they had best be removed. Gradual stripping off of pleura toward the spinal column and anteriorly is the next step. Care has to be exercised not to injure the sympathetic nerves, the vena azygos and the thoracic duct and, later on, the nervi vagi, while the esophagus is made more conspicuous by means of the introduction of a sound.

The fact that in all of the foregoing operations the operating field is situated from 12 to 14 cm. below the level of the skin, renders this way of advance technically very difficult.

As to the side of approach toward the posterior mediastinum, it seems best to advance from the right side, that is to say, by making the incision to the right of the spinal column.

Enderlen performed the first successful operation on the thoracic portion of the esophagus by removing from it an arrested tooth-plate, by means of mediastinal esophagotomy.

(Reisinger[2] successfully resected, by this route, a portion of the esophagus dilated in the longitudinal direction and closed the rent by sutures.)

Today it will be safer, when doing operations of this kind, to have differential pressure apparatus handy, in order to be prepared for accidental injury of the pleura.

Some surgeons adhere to this retropleural advance today; others favor the transpleural route.

The plan of an esophagotomy by the transpleural route is as follows: Thoracotomy in the seventh intercostal space, the incision to be lengthened, if necessary, by division of the angle of a few ribs upward and posteriorly (see below) or, resection of as many ribs within the oblique incision, as the case may demand; thorough exposure and separation of the affected portion of the esophagus; gentle milking of the same upward and downward, starting compression near the seat of the body and shutting off the operating field with rubber-covered branches of bayonet clamps above and below; careful tamponade; incision over the foreign body; extraction; suture; postoperative drainage of the pleural cavity. (Regarding drainage, see further down, under "Cancerous Stricture.")

II. Injuries of the Esophagus.

A. **Acute Perforation.**—(*a*) From the outside by bullet wounds, cut wounds, stab wounds; (*b*) from the inside by pointed foreign

[1] Deutsch. Ztschr. f. Chir., 1901, lxi, 440.
[2] Verhandl. d. deutsch. Gesellsch. f. Chirurgie, 1907.

bodies (pins, bones, tooth plates, etc.); attempts at extraction of the same; unskilled handling of the esophagoscope; (*c*) spontaneous rupture.

(*a*) *Bullet Wounds.*—Bullet wounds of the esophagus are a rare occurrence in war as well as in times of peace.

L. Bergheimer, in his thesis, 1903, "Bullet Wounds of the Neck Portion of the Esophagus," presented a series of 31 cases collected from the literature. In some the diagnosis is doubtful. They were taken from *The Medical and Surgical History of the War of the Rebellion*, 1861–65, and *The Sanitary Report of the German Armies in the Franco-German War*, 1870–1. Madelung briefly refers to this collection in a recent paper,[1] and adds 5 cases seen in the first three years of the late war, 1914–16, treated at the Strassburg hospitals. In 3 of these the neck portion had been injured; in 2, the thoracic portion. Three times only one side of the wall of the esophagus was perforated; in 1 both anterior and posterior walls were pierced; in another case an injury to the aorta complicated the lesion. The important nerves and vessels of the neck as well as larynx and trachea had escaped injury; but in some of the cases the lungs and spinal column were involved.

Diagnosis of acute injury of the esophagus in the neck portion so early that help by prompt operative intervention was still possible, proved a difficult task. This particularly for the reason that in none of the cases reported did food escape from the wound in the neck during the first days after the injury, not even when the external wounds were thoroughly enlarged, as had been done in three of the cases. The patients complained of difficulty in deglutition right after the injury, but all were able to swallow.

The location of entrance and exit of the bullet does not prove much. Where no exit occurred, a radiograph will assist in establishing the diagnosis of an esophageal injury. Esophagoscopy is contra-indicated. The proper procedures are: (1) in case of an injury situated high up, external esophagotomy, with feeding through a permanent esophageal tube; (2) in case of an injury in the thoracic portion, gastrostomy.

In the literature cases are reported of the spontaneous healing of small shot wounds in the esophageal wall. Escape of food and the formation of a temporary neck fistula do not always occur. Usually, however, mediastinitis will set in and cause the death of the patient. More of the seriously injured individuals will likely be saved in future by the combination of early, free incision of the wound in the neck, with thorough exposure and careful exploration of the neck portion of the esophagus; wide incision and drainage of mediastinal abscesses, and particularly the absolute operative exclusion of the injured portion of the esophagus for the purpose of nutrition by gastrostomy (or esophagotomy), with a permanent rubber tube in the esophagus.

The same reasoning holds good in cases of cut or stab wounds of the neck, involving the esophagus.

[1] Madelung, O.: Deutsch. med. Wchnschr., 1915, No. 5, p. 124.

(*b*) *Pointed Foreign Bodies and Attempts at Their Extraction,* also, not infrequently, the esophagoscope in unskilled hands, may cause perforation of the esophagus in its thoracic portion.

(*c*) *Spontaneous Rupture of the Esophagus* has been seen in a few rare instances in alcoholics in whom the elasticity of the esophageal wall is reduced in connection with the so frequently present esophagitis.

However, also in the absence of any organic disease of the esophageal wall, spontaneous rupture has been observed, *e. g.*, after a sudden overdistention in a severe attack of vomiting, when a large quantity of stomach contents was forcibly pressed into the entirely normal tube, or in consequence of a trauma, when the patient was subjected to a severe compression of chest and upper abdomen as, for instance, in accidents when coupling railroad cars. In the latter instance the rupture is probably also due to the fact that the stomach contents are suddenly pressed upward into the lower portion of the esophagus by the direct compression of the upper abdomen as well as to the strong reflex contraction of the muscles of the abdominal wall, due to the traumatism.

The rupture always penetrated all the layers of the tube and took place just above the cardia. Usually the rent ran longitudinally; in one case it was found circular.

In a remarkable case, published by G. Petrén[1] of the Surgical Clinic at Lund, a sudden air-pressure of 7 atmospheres produced within the mouth and pharynx, caused rupture of the esophagus. The man had been cleansing with compressed air from a pneumatic conduit the stuff box of a railroad car. When stepping over to the box on the other side, he kinked the tube with his hand and compressed the tip, which he held in his mouth, with his teeth. He stumbled and in doing so let the tube slip from his hand, when the air suddenly, under high pressure, entered his mouth and pharynx. Immediately afterward the man was very ill and died thirty hours later. At autopsy a vertical tear was found in the posterior wall of the esophagus; it appeared sharp cut, with straight edges, was 6 cm. long and commenced 1.5 cm. below the bifurcation of the trachea. There was also a far-reaching emphysema.

At the time of the rupture the patient often feels a sudden, intense pain, with the sensation of something inside having given way. Profound shock follows and soon a subcutaneous emphysema is noticed, starting in the supraclavicular space and rapidly spreading, sometimes over the whole body. It is caused by the entrance of air and gas into the posterior mediastinum. With increasing difficulty in breathing, and urinary retention, death usually sets in within twenty-four hours after the accident.

In view of the profound primary shock and the comparative uncertainty of the diagnosis, little can be done for the patient. The only operative procedure that might offer a ray of hope, is a prompt explor-

[1] Beitr. z. klin. Chir., 1909, lxi, 265.

atory thoracotomy, best, it seems, under negative pressure. When a rupture is found, the rent in the esophageal wall is to be closed by sutures, and the thoracic cavity—after proper cleansing—treated with air-tight drainage (see further down, on p. 102).

B. **Gradual Perforation.**—This is due to ulcerative processes of the esophageal wall, including peptic ulcer, to burns and broken down neoplasms. According to location, the perforation may occur into the mediastinum, the trachea, bronchi (lungs), pleura, pericardium and the large surrounding bloodvessels. Inasmuch as the perforation has been gradually prepared, and the surrounding tissue has become infiltrated in consequence of the inflammatory or neoplastic processes, air will not escape from the esophagus and, therefore, subcutaneous emphysema, so characteristic of an acute perforation, is hardly ever observed in these cases.

The only treatment the surgeon can offer patients of this type consists in maintaining nourishment through a permanent tube in the esophagus or a gastric fistula, and draining the pleura or pericardium if perforation took place into these cavities.

In cases of carcinoma behind the bifurcation of the trachea, a perforation into the left bronchus with subsequent putrid bronchitis, pneumonia and lung gangrene, is a frequent occurrence.

It is self-evident that in case of disease of the neighboring organs, the focus may also perforate into the esophagus.

Hemorrhage.—For the sake of completeness, hemorrhages into the esophagus will be mentioned. They occur when one of the adjacent bloodvessels, such as aorta, pulmonary artery, superior vena cava, vena azygos, etc., break through into the tube, or when a foreign body has injured these bloodvessels. Fatal hemorrhage has also been seen in case of the breaking of a varix in the lower portion of the thoracic esophagus, which develops in the presence of chronic liver disease (cirrhosis, etc.).

III. Acute Inflammation of the Esophagus (Acute Esophagitis).

Acute perforation of the esophagus will almost invariably be followed by an acute inflammation of the esophageal wall, combined with, or rather caused by an acute onset of a *septic posterior mediastinitis.*

The majority of these cases are doomed at present. Still, it is to be hoped that more of them will be saved in future by timely operative interference and proper, carefully conducted after-treatment.

As regards posterior mediastinotomy, further clinical observations must decide which one of the several procedures should be considered the method of choice; whether the Rehn-Enderlen method, with a wide, loose tamponade of the peri-esophageal connective tissue; or whether a perpleural (transthoracic) incision with subsequent free drainage of the posterior mediastinum through the respective pleural cavity—usually the left. In either method the patient is fed through a permanently placed esophageal tube, introduced into the stomach

through the nostrils, or by way of a gastrostomy. It is certain, however, that only active surgical treatment offers the patient any hope of recovery in case of such an emergency.

Another cause of acute esophagitis is the swallowing, either accidental or with suicidal intent, of a corrosive (caustic lye, carbolic acid, etc.).

In examining such cases the esophagoscope should not be used until the inflammatory reaction has subsided. Ordinarily this will take place within a week or ten days.

The appearance of the acutely inflamed region of the esophagus is the same as that of other mucosa-lined canals, viz., intense reddening, diffuse or circumscribed; marked congestion of the capillaries, which later on, when serous effusion has set in, becomes edematous.

IV. Chronic Inflammation of the Esophageal Wall (Chronic Esophagitis, Subacute Posterior Suppurative Mediastinitis, Ulceration).

1. *Chronic esophagitis* occurs as a continuation of an acute inflammation, or as a sequela to the stasis of food particles above a stricture, or through such stasis in a diverticulum. It is also found in alcoholics under the clinical picture of a chronic catarrhal inflammation.

2. An *abscess* will develop if, despite its septic character, the infection of the connective tissue within the posterior mediastinum is of a low degree of virulence (subacute posterior suppurative mediastinitis). Such abscesses, in turn, may cause local gangrene of the esophageal wall, by their interference with the blood supply of the esophagus; they also may penetrate into the trachea.

An important contribution to this chapter has recently been made by V. Gaudiani,[1] of New York City. After a brief review of the various methods of approach, he cites 8 cases of abscess in the posterior mediastinum, collected from the literature, in all of which a cervical operation was performed. In one instance, a case of gunshot wound of the thoracic portion of the esophagus, Rasumowski[2] succeeded in saving a boy of twelve years with a suppuration in the posterior mediastinum, by means of a free neck incision and drainage of the pus cavity, though only after months of faithful treatment. The abscess extended from the neck into the posterior mediastinum for 15 cm. and communicated with the trachea through a small opening. The patient was kept in Trendelenburg's posture during the after-treatment and fed through a tube for nine months.

To these eight cases the author adds two observations of his own.

His conclusions are:

"Abscesses in the posterior mediastinum must be treated by incision through the dorsal or cervical route.

"All abscesses located at any point in the posterior mediastinum may be dealt with by the dorsal incision, but its real indication is for cavities located low in the mediastinum below the arch of the aorta from the fourth to fifth dorsal down.

[1] Ann. Surg., May, 1916, p. 523. [2] Hildebrandt's Jahresbericht, 1900, p. 411.

"All abscesses situated at the level of, or above the fourth dorsal may be successfully opened and drained through the cervical incision. Only secondarily a dorsal mediastinotomy may be necessary.

"Cervical mediastinotomy has a rather wide range, principally because of the fact that many abscesses have their origin from the superior portion of the esophagus, or from the retropharyngeal space, and only secondarily migrate into the chest.

"Abscesses, whose origins are in the superior part of the mediastinum, have, according to von Hacker, no tendency to spread downward. Because of the lessened density of the cellular tissue above the heart, they easily migrate toward the neck."

3. *Ulceration* (peptic, tuberculous, syphilitic). The peptic ulcer is found below the diaphragm, close to the cardia. Its occurrence is attributed to functional insufficiency of the cardia, or to the manner of closure of the proximal end of the stomach, viz., "kinking of the esophagus at the hiatus, due to pressure of the gastric fundus and of the perihiatal structures. This permits the stomachal contents to invade the lower end of the esophagus" (Jackson). As a matter of fact an esophageal peptic ulcer occurs only in the abdominal portion of the esophagus, while those of tuberculous or syphilitic origin are always found above the diaphragm, at the places of physiological strictures. At the tracheal bifurcation the perforation of a peribronchial lymphatic gland may be the cause of the trouble.

"Dysphagia is present in a goodly proportion of cases, and this dysphagia is one of the main diagnostic points in the differentiation of ulcer of the stomach.

Immediate pain on swallowing and tenderness over the sternum are characteristic symptoms of esophageal ulcerations. These symptoms are more or less constantly present when the ulcer is at the fourth constriction."[1]

The usual standard methods of examination, enumerated above, particularly esophagoscopy, preceded by the string test of Einhorn (Sheehan), the consideration of other signs of tuberculosis, a positive Wassermann, and exclusion of the other alternatives producing ulceration within the esophagus, *e. g.*, a buried foreign body or a neoplasm, must be combined to advance and establish a diagnosis of this kind.

For treatment: topical application of a 20 per cent. silver nitrate solution, the insertion of Einhorn's duodenal tube for feeding and large doses of bismuth subnitrate, combined with argyrol crystals and magnesia usta, three or four times daily by mouth, are recommended. After the duodenal tube is removed the string test is again employed to note the progress of healing. Many times one gets a negative test, showing that the ulcer has healed. (Sheehan, l. c.).

Chronic syphilitic esophagitis may yield to an antispecific regimen —same as syphilis of the stomach—and to direct treatment through the esophagoscope.

[1] Sheehan, Jos. E.: New York Med. Rec., February 21, 1920, p. 319.

Lest a stricture develop, a tuberculous ulceration demands the same topical application and careful observation as the others.

V. Stricture of the Esophagus.

The remaining important affections and diseases: congenital anomalies, cardiospasm, diverticulum, tumors of benign and malignant

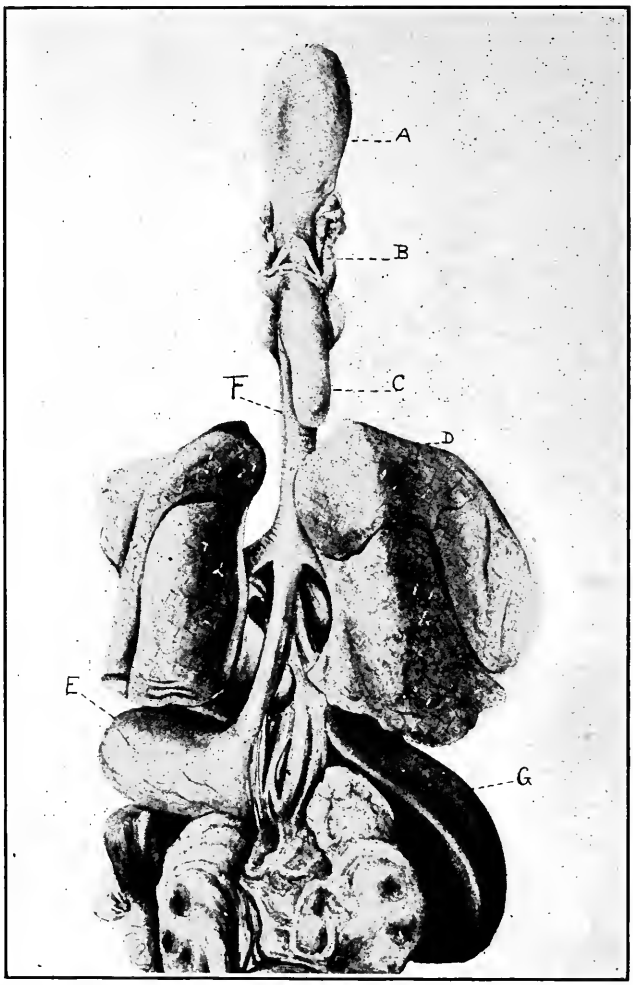


FIG. 26.—Esophagotracheal fistula; posterior view. *A*, tongue; *B*, larynx; *C*, blind esophageal pouch; *D*, lungs; *E*, stomach; *F*, trachea; *G*, liver. (Losee, Bulletin of the Lying-In Hospital of the City of New York.)

character, are best grouped under the heading of "Stricture of the Esophagus." Each of these diseases encroaches temporarily or permanently upon the lumen of the esophagus and produces difficulty in deglutition.

Congenital Anomalies.—Quite a variety of these have been observed. The esophagus may be bifid; it may be in communication with its lower portion through a typical congenitally strictured canal, several centimeters long (Fig. 20) or it may end in a blind imperforate pouch (Fig. 26). This usually is from 2.5 to 4 cm. long. In the majority of cases there exists a communication between this pouch and the air-passages (Fig. 27).

A fibrous cord may extend from the lower pole of the rudimentary esophagus to the cardiac end of the stomach; or, a few muscle fibers may run from the termination of the sac downward on the posterior wall of the trachea.

In a third variety there is absolutely no connection with the stomach.

The fistulous communication with the trachea usually takes place at the bifurcation; sometimes it unites with its posterior wall from 1.2 to 3 cm. above it.

The esophagus may in its cardiac end be perfectly developed and have its normal position and course upward, but terminates at the bifurcation of the trachea, with which it often forms an anastomosis.

These malformations have an embryological explanation in that the proximal and distal portions of the esophagus have different sources of origin.

The buccal cavity, pharynx and upper extremity of the esophagus develop from the ectoderm, the intestinal tract including the distal portion of the esophagus and the respiratory apparatus from the endoderm.

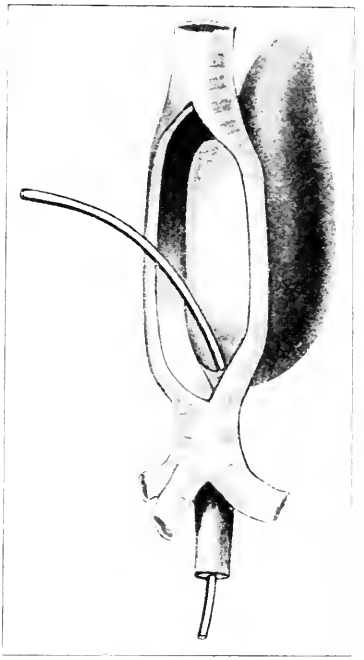


Fig. 27.—Congenital esophagotracheal fistula. (MacKenzie.)

Fistulous communications between the esophagus and the trachea are almost always situated at the bifurcation and the conclusion may be drawn that the membrane separating esophagus and trachea closes last at this spot (Losee).[1]

The possibility of such an occasional congenital anomaly must be ever present in the mind of the attending physician in a case of rather unusual, but typical symptoms in the behavior of the newborn. Dr. Edward D. Truesdell, of the staff of the Lying-in Hospital, New York, was able to make the exact diagnosis of such a malformation, having had, a year previous, the opportunity to observe a similar case. The

[1] Bulletin of the Lying-In Hospital of New York City, January, 1914.

infant became asphyxiated at intervals of thirty minutes to one hour, which condition was promptly relieved by the removal of a large quantity of thick, yellow mucus from the pharynx. The lower end of the crib was elevated and with the mucus flowing from the baby's mouth, no further spasms occurred. It nursed as if it were very hungry, but only for a few minutes, at the end of which time it choked, became asphyxiated and relief was obtained by lowering its head.

Diagnosis.— The diagnosis in such cases is made by passing a soft rubber catheter down the esophagus. It will be arrested at from 10 to 11 cm. (4 to $4\frac{1}{2}$ inches) from the alveolar border. With an *x*-ray stilette in position the radiogram shows the lower end of the sac. The sooner after the birth of the child the diagnosis can be made the better.

From a therapeutic standpoint immediate gastrostomy is alone indicated. Whether it will bring relief, depends upon the peculiarities of the case. If a free communication of a patent lower portion of the esophagus exists with the air passages, bronchopneumonia will soon end the baby's sufferings, for only closure of the cardia could prevent it, and this, being in itself a difficult operation technically, would come too late, as regurgitation of mucus and food from the stomach after the first attempts at feeding will have immediately started a pulmonary affection. Still, some such cases have been known to live. In one "a valve-like fold of the mucosa seemed to close the fistula so that no food escaped into the trachea."

Treatment.— The worst a doctor can do—and not infrequently does—is to force a stiff bougie down beyond the obstruction. He will invariably perforate the esophageal pouch and cause the death of the child. If he has diagnosed the trouble, he should promptly give the parents the prognosis. These infants usually die from two to twelve days after birth, regardless of whatever treatment.

Should conditions be less complicated, a primary gastrostomy may keep the child alive.

Children being fed through a gastric fistula *can* grow up, but they usually remain underdeveloped (one personal observation: Impermeable cicatricial stricture of the esophagus; gastrostomy in fourth year of life; patient still living, twenty-four years old).

Spastic Stenosis of the Esophagus (*Cardiospasm*).—Cardiospasm is a spastic contraction of the distal end of the esophagus at or near the cardia. It finds its analogy in pylorospasm and other spasmodic contractions in the course of the gastro-intestinal tract. v. Mikulicz compared it with the spasmodic contraction of the sphincter ani muscle, produced by the presence of a fissure. Lately Jackson has proposed to drop the term "cardiospasm" and call the disease "hiatal esophagismus."

Whether it occurs at the cardia proper or above it at the foramen esophageum has not yet been definitely determined.

The contraction may be of short or long duration. It may last for weeks, for months or for years.

Etiology.—The cause of the trouble is most likely a hyperirritability of the pneumogastrics, a so-called "vagotonia," and of the sympathetic system: "sympathicotonia." It is known today that both systems of nerves supply the motor function of the lower esophagus and cardia, though the chief supply is derived from the two nervi vagi. The hyperirritability may be due to a general affection of the vegetative nervous system, or to a reflex from pathological lesions of intra-abdominal organs, the genito-urinary system, pleura, etc. It may also be caused by general intoxication and by local lesions, such as a fissure, erosion, ulcer, etc., at or near the cardia.

FIG. 28.—Cardiospasm, fusiform type. Note pouch above diaphragm.

Diagnosis.—A routine examination, as outlined above, under "Examination of the Esophagus," will usually bring out the correct diagnosis. The radiograph will show the existence of a greatly dilated tube of fusiform (Fig. 28) and pear-shaped (Fig. 35) or γ-shaped appearance (Figs. 29 and 35). Important features are, that the esophagoscope fails to reveal a pathological change—there is no characteristic endoscopic picture of cardiospasm—and that a soft tube will not enter the stomach, while an olive readily passes the cardia.

In some cases the olive can be made to pass only by using Plummer's thread method (see under "Cicatricial Stricture," page 70).

The contraction of the cardia disappears under deep general anesthesia, also often temporarily after the internal administration of atropin.[1]

FIG. 29.—Cardiospasm, α-type. (Courtesy of Dr. L. Th. Le Wald.)

Treatment.—*Non-operative Methods.*—The average case of cardiospasm yields to mechanical stretching of the cardia. This can be done by way of the stomach or through the mouth. v. Mikulicz was the first to incise the stomach through a laparotomy wound, to introduce a long forceps through the cardia from below and spread its rubber covered branches in various directions.[2] Under such treatment five patients were cured and stayed cured during the time of observation; one patient, who developed a perigastric abscess, was much improved.

[1] The so-called "diffuse, idiopathic dilatation of the esophagus" is most likely also due to cardiospasm.

[2] Centralbl. f. Chir., 1904, p. 1362.

Later v. Mikulicz passed his fingers through the cardia and dilated with them, in place of the forceps, also successfully.

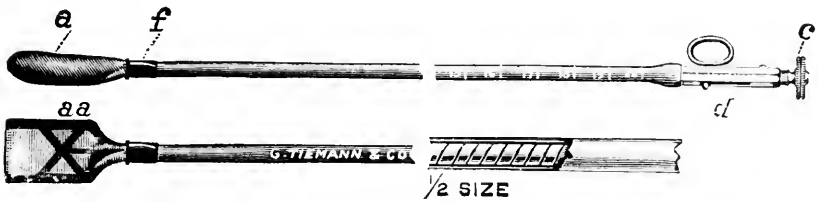


FIG. 30.—Einhorn's cardiodilator.

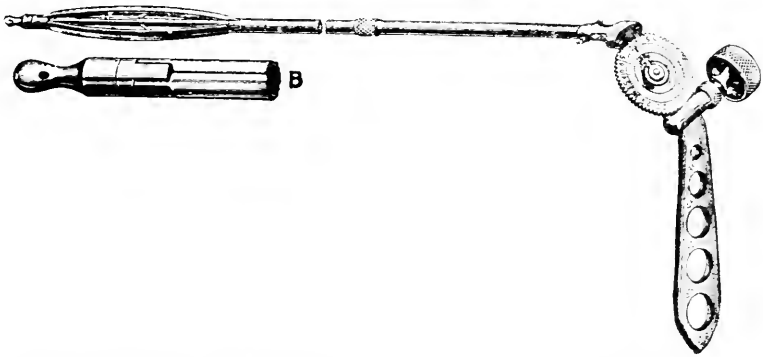


FIG. 31.—Mosher's esophageal dilator. *B*, actual size of distal end. (Jackson.)

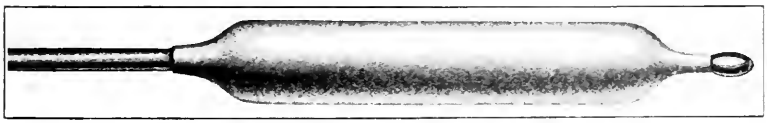


FIG. 32.—Plummer's hydrostatic cardiodilator; distended.

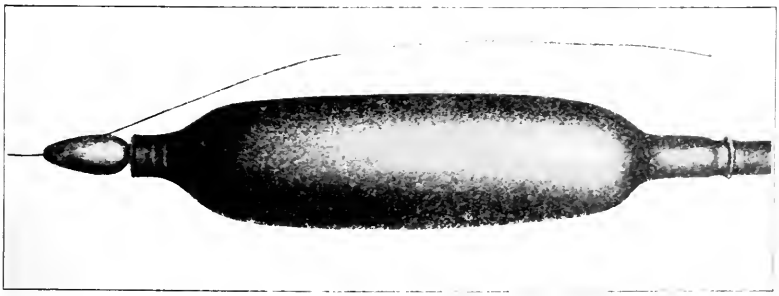


FIG. 33.—The same with fenestrated olive tip, threaded. Patient has been made to swallow six yards of a silk thread preliminary to the use of the dilator. The thread, passing through the coils of small intestine, becomes engaged in them, so that it cannot be pulled out when drawn taut. With the olive threaded, the cardia can now be entered by the latter without difficulty, and the dilator introduced. About its middle third is made to engage the cardia. (See under Cicatricial Stricture, Fig. 45.)

In more recent years the well-known dilators of Gottstein, Einhorn (Fig. 30), Mosher (Fig. 31) and Plummer (Figs. 32, 33 and 34), passed by way of the mouth, have been successfully used in many cases and greatly simplify the procedure of v. Mikulicz. The cardiac ring is stretched in all directions of the compass. Now and then one single

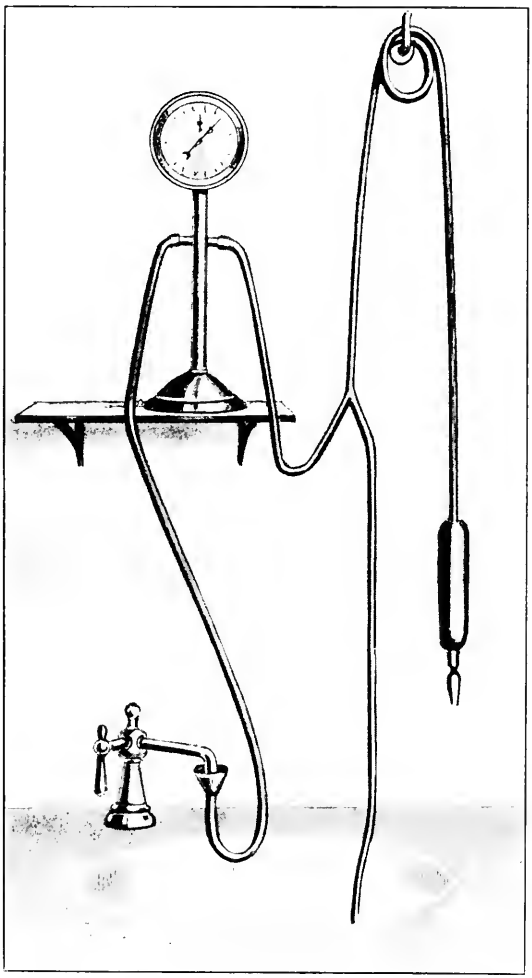


Fig. 34.—Plummer's dilator, showing arrangement of tube and attachment. The water tap has been opened and the instrument is allowed to fill, being controlled by a gauge. A pressure of 575 mm. has been found to be sufficient and safe in the great majority of cases.

divulsion accomplishes a cure, but ordinarily repeated sittings are required. Certainly, divulsion should be tried first in every case that permits of the passage of the instrument into the stomach.

In the course of the last six years Einhorn has made use of repeated "retrograde" dilatation in a number of cases of *impermeable* cardio-

spasm, viz., in patients in whom bougies refused to pass from above. He employed his instrument for retrograde stretching of the pylorus for the purpose of stretching the cardia. Every case thus treated (10) was cured.[1]

However, not all cases of this type yield to stretching. In spite of repeated divulsions the spasms occasionally return; in other words, we also meet with *inveterate* cases which cannot possibly be improved by this method. If here an attempt is made to introduce a bougie or dilator into the stomach, the instrument will often slip sideways into a pouch which has formed above the diaphragm. The help of the esophagoscope is required to accomplish the mere task of this introduction. But even should in these cases divulsive stretching of the cardia be successful, the result will nevertheless often be found unsatisfactory, as the attenuated muscular pouch of the esophagus has, through atony, lost its contractility.

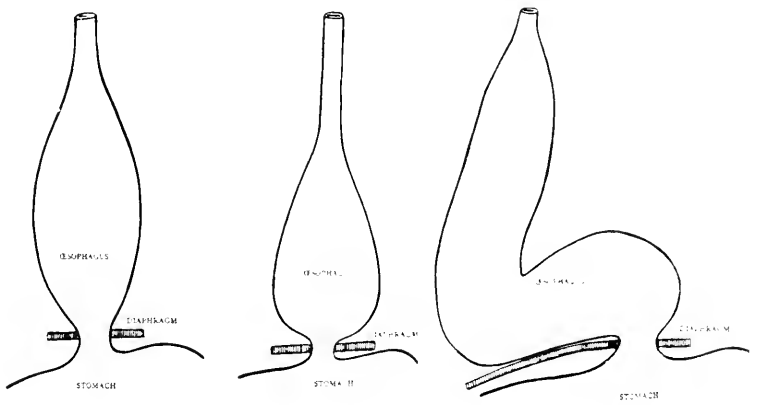


FIG. 35.—*1*, fusiform dilatation of the esophagus; *2*, pear-shaped dilatation of the esophagus; *3*, Y-shaped dilatation of the esophagus. (V. V. S. Lambert.)

In rare cases the pouch will sometimes become Y-shaped, curving toward the right and producing there a dead space, which is found to be below the level of the cardia (Lambert). (See Fig. 35.)

This group of cases of cardiospasties we call "intractable."

Operative Treatment.—In order to achieve here better results *operative methods* are resorted to.

Three different types of operative procedures are at our disposal:

1. *The cardia proper is not attacked: Vagolysis, combined with Esophagoplication*, with the help of thoracotomy.[2]

2. *Operations on the Cardia Itself:* (*a*) Cardioplasty by the abdominal and thoracic route; (*b*) the longitudinal incision of the seromuscular layer of the cardia.

3. *Esophagogastrostomy.*

[1] Einhorn: Diseases of the Stomach, 6th ed., 1917, p. 493.

[2] Willy Meyer: Ann. Surg., liii, p. 293; Trans. New York Surg. Soc., 1911; Jour. Am. Med. Assn., May 20, 1911, lvi, 1437; Am. Jour. Surg., June, 1912.

1. *Vagolysis combined with esophagoplication:* This operation was first carried out by me at the Lenox Hill Hospital on May 31, 1910. Since then I have employed it again in two cases.

CASE I.—Female, age forty-seven years; difficult deglutition of long standing; large esophageal pouch above the diaphragm; emaciation First step: gastrostomy. A few weeks later (May 31, 1910), under positive differential pressure (cabinet), transthoracic exposure of the esophageal pouch; bilateral vagolysis, starting at the hiatus and carried several inches upward. The short branches of the nervus vagus that entered the pouch from both sides are severed. Plication of the pouch in two layers with interrupted silk sutures. Closure of thorax. In the course of the after-treatment unimpeded deglutition returned. No further instrumentation. Recovery. Presented before the New York Surgical Society November 23, 1910. In January, 1911, contracted influenza-pneumonia, after which a thoracic esophageal fistula became established in the scar of the chest wall, most likely due to perforation of one or more of the plicating silk sutures. A subacute suppurative posterior mediastinitis developed, to which the patient succumbed a year after the operation. Swallowing continued with perfect ease to the last.

CASE II.—Male, aged forty-four years; dysphagia for last five years. Operation May, 1911; same plan followed as in Case I, but no primary gastrostomy this time; double vagolysis with esophagoplication (one fold only), chromicized catgut; primary drainage of thoracic cavity. Here also easy deglutition returns a few days after the operation; patient soon takes full diet; considers himself cured. Later in the after-treatment the drainage tube slipped into the thorax and had to be removed by a second operation, prolonging the time of drainage. It seems that the formation of more abundant cicatricial tissue around the esophagus, due to the extended drainage, was the immediate factor in disturbing the good functional result primarily obtained, as, gradually, more difficult deglutition returned. (For a continuation of the patient's history, see below, under "Cardioplasty, Thoracic Route.")

CASE III.—Male, aged forty-six years. Operative procedure of Case II. He made a rapid recovery, but was not benefited by the operation. He evidently had a cicatricial stenosis at the cardia, probably consecutive to a peptic ulcer. Further operating refused by patient.

Reviewing these cases, it would seem that the prompt return of easy deglutition was due to the double vagolysis rather than to the single or double esophagoplication. The latter, however, should always be added in the presence of a large esophageal pouch. In cases of only moderate dilatation of the esophagus, I believe, the plication may be omitted. Additional operative corroboration as to this point is needed. Still, it would seem that, at the present moment, transthoracic double vagolysis, owing to its simplicity, represents the operation of choice in intractable cases of this type, provided the surgeon prefers the transthoracic route. In the light of our views on the etiology of cardiospasm it certainly appears to be a logical procedure.

2. *Cardioplasty* (*a*, i) by the abdominal route (Wendel,[1] 1909). Osteoplastic resection of costal arch; cardia pulled forcibly down into abdomen; clamps placed above and below; careful tamponade; longitudinal incision of cardia; transverse suture which is supported by a fold of the stomach stitched over the suture and fastened to the serosa of the diaphragm. Gastrostomy. Recovery; perfect functional result.

Cardioplasty (*a*, ii) by the thoracic route (author), tried in the case of the second patient, who had been treated with vagolysis and esophagoplication (see above). Patient asked for operative improvement if possible, as repeated divulsion of the cardia brought no relief:

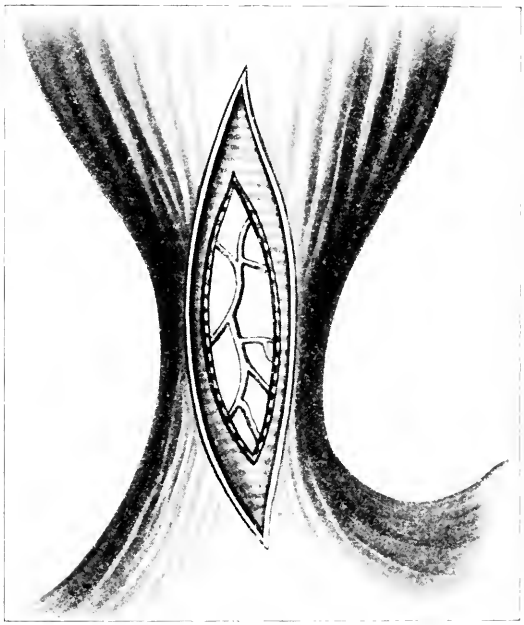


FIG. 36.—Longitudinal incision of seromuscular coat of cardia, anteriorly as well as posteriorly, preserving the mucosa, on the outside of which the network of blood-vessels is visible.

February 13, 1913, resection of seventh and eighth rib; gradual exposure of the cardia in a mass of dense cicatricial tissue; it is found fixated within the foramen esophageum and cannot be pulled forward into the thoracic cavity. Longitudinal incision; transverse suture; in addition: free fascia transplantation with a piece taken from the fascia lata, made to surround the field of operation like a cuff; tamponade; gradual closure by granulation. Immediate functional result not satisfactory; gradually improved by means of endoscopic treatment by Dr. Yankauer, who removed a silk suture through the esophagoscope. In December, 1917, solid food was nicely swallowed; at times

[1] Centralbl. f. Chir., 1909.

some difficulty, the cause of which remained obscure. Since then lost sight of.

In view of the great mobility of the lower end of the esophagus and of the cardia within the foramen esophageum of the diaphragm, it is probable that a *primary* cardioplasty by the thoracic route, would prove a much easier procedure.

(*b*) Another very simple and, as it seems, effective operation for intractable cardiospasm has recently been recommended by the Leipzig Surgical Clinic.[1] E. Heller,[2] first assistant of that institution, after incising the diaphragm from below, mobilized the cardia and then divided its layers anteriorly and posteriorly, perpendicularly down to the submucosa, in length of several centimeters (Fig. 36). These two wounds remained unsutured. The result was splendid; formation of diverticuli were not observed. This operation corresponds to the one for the operative treatment of pylorospasm (Fredet-Rammstedt).

Esophagogastrostomy.—(*a*) *By the abdominal route*, uniting the supradiaphragmatic esophageal pouch with the stomach.

Heyrowsky[3] cites two cases. In one, the osteoplastic resection of the costal arch made the approach to the cardia easier; in the other, an oblique incision, parallel to the left costal arch, nicely exposed the operating field. In both cases the anastomosis was made with a double row of interrupted sutures. The line of suture was covered with the vault of the stomach and drainage of the subphrenic space added. Uninterrupted recovery in both instances.

A. V. S. Lambert[4] accomplished the anastomosis with the help of pressure necrosis by forceps.

Female, aged forty years; typical pouch above the diaphragm of the χ-variety. No improvement by dilatation of the cardia. Operation February 1, 1913. Left rectangular flap incision into abdomen. Osteoplastic resection of left costal arch by means of a special cut beneath the left mammary gland, by which the seventh, eighth and ninth ribs were divided near the attachment of their cartilages. The opening of the gastrostomy, which had been done at a previous sitting, dissected from the anterior abdominal wall and temporarily closed by a purse-string suture. Exposure of the cardiac opening of the stomach. Incision of the diaphragm next to the cardia. The lower end of the dilated esophagus which was marked by a bougie that had been introduced through the mouth, was freed from surrounding structures by blunt dissection, pulled into the abdominal cavity and fixated in this position by means of interrupted catgut sutures, the border of the diaphragmatic incision being stitched to the esophagus. Now the purse-string suture which had closed the gastrostomy opening, was divided and a long clamp passed through this opening upward in such a way that one blade of the clamp rested in the drawn-down esophageal pouch, the other within the esophagus, introduced upward through the cardia.

[1] Payer, E.: Verhandl. d. deutsch. Gesellsch. f. Chir., 1914, p. 749.
[2] Mitt. a. d. Grenzgeb., 1914, xxvii, 141.
[3] Arch. f. klin. Chir., 1913, c, 703.
[4] Surg., Gynec. and Obst., 1914, xviii, 1.

By closing the blades, the clamp became an esophagogastrotribe, similar in principle to the enterotribe. A row of catgut Lembert sutures united the contiguous portions of the dilated esophagus and the stomach. A soft-rubber catheter was passed alongside the clamp into the stomach for feeding purposes. The gastrostomy fistula was reëstablished and attached to the abdominal wall. Drainage. Closure. Six weeks after the operation the patient was able to eat everything, without discomfort or vomiting.

(*b*) *By the Thoracic Route (Transpleural Esophagogastrostomy).*—K. Henschen[1] proceeded in this way in the case of a twenty-year-old man who had shown symptoms of cardiac stenosis for seven years. Specialistic treatment had been of no avail. *X*-rays showed an almost entirely impermeable stricture 3 cm. above the cardia with enormous distention of the esophagus, of the *Y*-variety, above.

Preliminary gastrostomy (Witzel). Soon afterward, intercostal incision in left seventh interspace; exposure of lower segment of esophagus; division of diaphragm; blunt mobilization of cardia and stomach which was pulled up into the thorax. Wide anastomosis between the esophageal sac and the stomach fundus, made with a double row of single sutures. Closure of diaphragm and of mediastinal pleura by a number of interrupted silk sutures, the anastomosis being placed below diaphragm.

The rather difficult technic of the work was much simplified by the injection of a 2 per cent. solution of novocain into and around the phrenic nerve, where the latter runs in a fold of the pericardium. This produced a temporary paralysis of the respective half of the diaphragm, lasting over two hours. Simultaneously, both nervi vagi had been blocked with a novocain solution. The thorax was closed. Undisturbed convalescence. A short time thereafter the patient was able to take his food without difficulty.

This is the first recorded case of a successful esophagogastrostomy for cardiospasm by the transpleural route.

All these procedures need more careful testing; probably a number of them are recommendable. The operator must select the one that, according to the clinical and *x*-ray findings, appears best adapted to the case in hand. Any one of them is indicated only after instrumental cardiodilatation at repeated sittings has failed to bring relief.

But the future bids fair to corroborate the assumption that, in the light of modern surgery, there seems to be still a chance for improvement or cure even of supposedly intractable cardiospasm.

Compression Stenoses of the Esophagus.—They may be produced by a great variety of pathological conditions.

We exclude from this consideration retropharyngeal abscesses and tumors of the neck; further, pleural and pericardial effusions, deformities of the spine, etc., all of which can compress the esophagus in any portion of its course. These diseases are treated in the text-books on internal medicine and general surgery.

[1] Centralbl. f. Chir., 1916, No. 2.

What we shall here briefly consider, from a diagnostic point of view, is the compression of the esophagus from without, by an aortic aneurysm, by tuberculous, syphilitic or malignant peribronchial lymphatic glands, and by tumors of the posterior mediastinum. We will then proceed to discuss the intermittent compression of the esophagus by a pressure diverticulum.

Aortic Aneurysm.—Whether developing at the arch or in the descending portion of the vessel, the aneurysm is bound to compress the esophagus, as the latter is closely attached to the aorta by connective

FIG. 37.—Stricture of esophagus due to the presence of an aneurysm of the aortic arch.

tissue as well as by the short esophageal arteries (see under "Anatomy," page 21). The tube can, therefore, be only slightly pushed aside. As soon as the aneurysm has acquired some size, it is bound to compress the esophagus (Fig. 37).

In view of the possibility of an aneurysm being the cause of esophageal stenosis, it appears unwise and dangerous to let sounding be the first instrumental step in refining the diagnosis of an esophageal

obstruction. Just imagine the calamity, if the sound should perforate the aneurysm and the patient bleed to death at the doctor's office! And, clinically, there may be no possibility of establishing the diagnosis of thoracic aneurysm, neither by palpation, nor by percussion, nor by auscultation, even at a time when the sac is at the point of breaking into the tube. Often the typical clinical symptoms of an aneurysm become manifest only after the sac has become attached to the thoracic wall.

The first step in the routine examination of doubtful cases should be radiography with fluoroscopy. The *x*-ray picture will present a sharply defined round contour of the intrathoracic tumor, and with the fluoroscope one can see the pulsation.

Esophagoscopy should be added in cases which still remain somewhat doubtful and where corroboration is needed. The expert esophagoscopist will readily differentiate the pulsating of an aneurysmatic sac from the normal pulsatory movements ordinarily observed with the esophagoscope.

That the tube must be handled with extreme gentleness, goes without saying.

Tuberculous, Specific or Malignant Peribronchial Lymphatic Nodes may constrict the esophagus. A glance at Fig. 5 will show this. The same holds good in the case of posterior mediastinal tumor.

Posterior Mediastinal Tumor.—Radiography will be here of great assistance in establishing the diagnosis. If the *x*-rays fail to make out an aneurysm, but show a shadow at the bifurcation, and if the sound finds and locates a stricture, and the esophagoscope does not demonstrate any pathological changes of the wall of the tube at this distance from the teeth, the possible existence of a posterior mediastinal tumor comes into consideration.

Pressure or Pulsion Diverticulum.—*Location.*—The majority occur at the junction of the pharynx and esophagus, at a typical spot: somewhat above the so-called pars fundiformis of the cricopharyngeal muscle, opposite the cricoid cartilage, the "weak spot" of the esophagus (Fig. 38). They are usually situated posteriorly and somewhat to the left. Exceptionally, they have been found intrathoracically. They vary greatly in size, have a distinct neck and are most commonly found in males over forty years of age. The pouch is evidently acquired, not congenital.

Etiology.—As *predisposing factors* for the formation of a diverticulum must be mentioned the upper physiological stenosis of the esophagus behind the cricoid cartilage; the deficient quantity of the longitudinal muscular fibers at the upper end of the esophagus; occasionally also the presence of a compressing goitre; or a cicatricial stricture. As *exciting causes* may be mentioned the continually recurring pressure of the food at this spot in normal deglutition, particularly of food too rapidly swallowed and improperly masticated, and direct injury to the wall of the gullet by pointed or hard substances.

Another form of diverticulum is called *traction diverticulum*, because

it is due to the traction in an outward direction of the esophageal wall by the attachment of a circumscribed spot of the same to an inflamed and later on shrunken peribronchial gland or to a vertebra.

Symptoms.— The principal complaint is dysphagia. The sac fills and empties intermittently. If distended by food, it not infrequently compresses the lumen of the esophagus to such an extent, that a bolus cannot travel down and is at once regurgitated. A small tumor can then often be palpated on the left side of the neck just above the

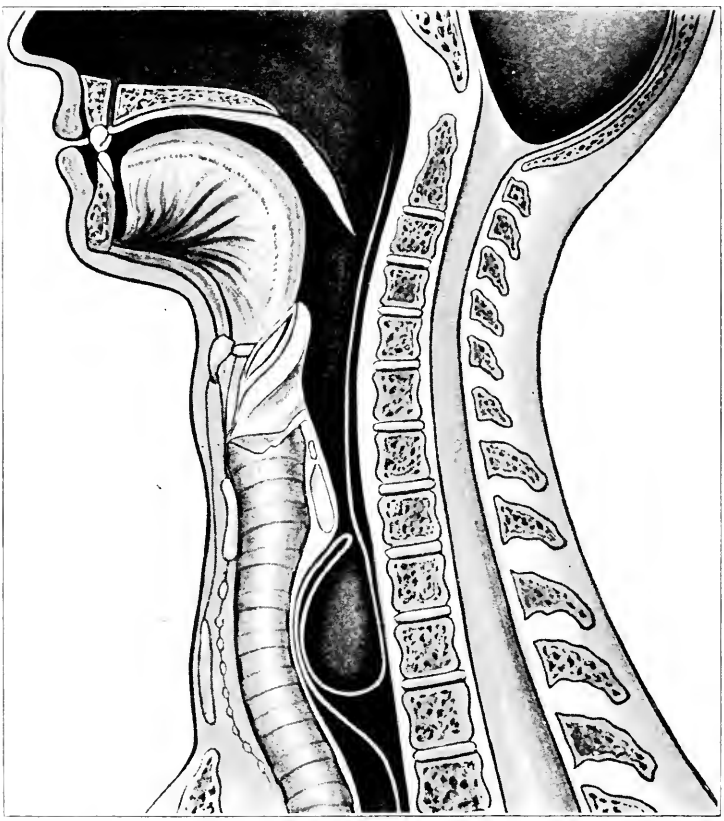


FIG. 38.—Illustrating a pressure diverticulum distended. The compression of the trachea, as shown, is the artist's free invention. These patients hardly ever complain of difficulty in breathing.

clavicle. When the sac becomes overdistended, it throws out its contents which then reappear in the mouth. In one of my patients, successfully operated upon for this trouble, the contents were usually brought up through the nostrils.

As a matter of necessity, the retained and stagnating food decomposes and causes an annoying fetor ex ore.

The course of the disease is chronic. Lung complication due to aspiration may set in; the nutrition of the patient suffers. Should

ulceration form within the sac, the latter may perforate and cause acute fatal posterior mediastinitis. Carcinoma has been seen to develop in the pouch, when the latter was left unattended.

The other variety of esophageal diverticulum, the traction diverticulum, hardly ever produces obstructive symptoms. Only if it becomes combined with a pulsion diverticulum (traction-pulsion diverticulum) can food accumulate in the sac and cause symptoms.

Diagnosis.—Among the various factors of routine examination as set forth above, radiography clearly takes the first place. Its results are definite and unmistakable. A round shadow is seen on the plate just above the suprasternal notch, caused by the accumulation of the

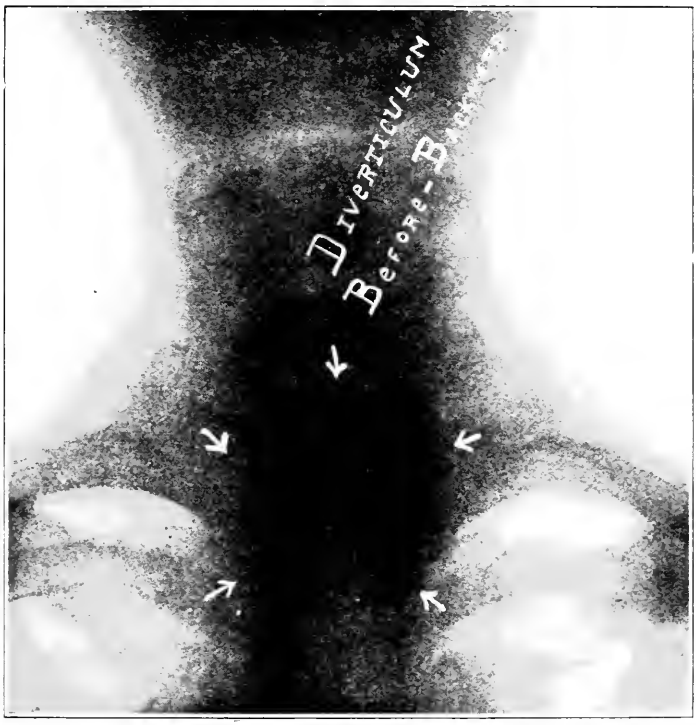


FIG. 39.—Pressure diverticulum of esophagus: front view.

swallowed bismuth paste (Figs. 39 and 40). This result is so characteristic that it alone could establish and sustain the diagnosis. However, here as in other diseases, corroboration is desirable. Thus, one will sometimes notice a doughy swelling should it happen that palpation is done at a time when the pouch is filled.

Repeated sounding will show a peculiar pathognomonic phenomenon, namely, that the bougie will pass with perfect ease at times, while at other times it finds an absolute obstruction 16 to 19 cm. from the teeth. If the *x*-ray stilette was used and the radiograph then promptly taken, its tip will be seen in the sac.

Esophagoscopy for diagnostic purposes can be dispensed with. However, if a trained esophagoscopist is available, additional corroboration is welcome (Fig. 41).

Treatment.—Active therapy, *i. e.*, the extirpation of the diverticulum, is always indicated. If general anesthesia is feared on account of the patient's advanced age, a carefully conducted scopolamine-morphine sleep in combination with local novocaine-anesthesia will enable successful performance of the various steps of the operation. The latter can be done in one and in two stages. The one-stage operation consists in typical exposure of the cervical portion of

FIG. 40.—Pressure diverticulum of esophagus; lateral view.

the esophagus, as done in external esophagotomy, isolation and removal of the sac. O. C. Gaub recommends to present the sac in the esophagotomy wound with the tip of the esophagoscope tube in the diverticulum (Fig. 41). The surgeon then seizes the bottom of the pouch with forceps and ligates and transfixes the neck of the sac while the esophagoscopist withdraws the tube to the hypopharynx and inserts it in the lumen of the esophagus. Thus the normal lumen of the esophagus is indicated, while the surgeon amputates the pouch. Gaub has thus twice successfully operated with Jackson's[1] assistance. This certainly

[1] Diseases of Esophagus, 1915, p. 551.

appears very pretty and ingenious. Ordinarily it is not difficult to find and isolate the sac.

The question how best to treat the neck of the diverticulum, *i. e.*, its communication with the esophagus, deserves brief discussion, because thereon depends to a great extent the aseptic, uncomplicated course after operation. Provided the neck is not inordinately wide and thick, the procedure customary in appendectomy will suffice, viz., firm ligation of base with stout chromicized catgut, close to the esophageal wall; clamping in front; division; cauterization of the stump with the active cautery; purse-string catgut suture in order to bury

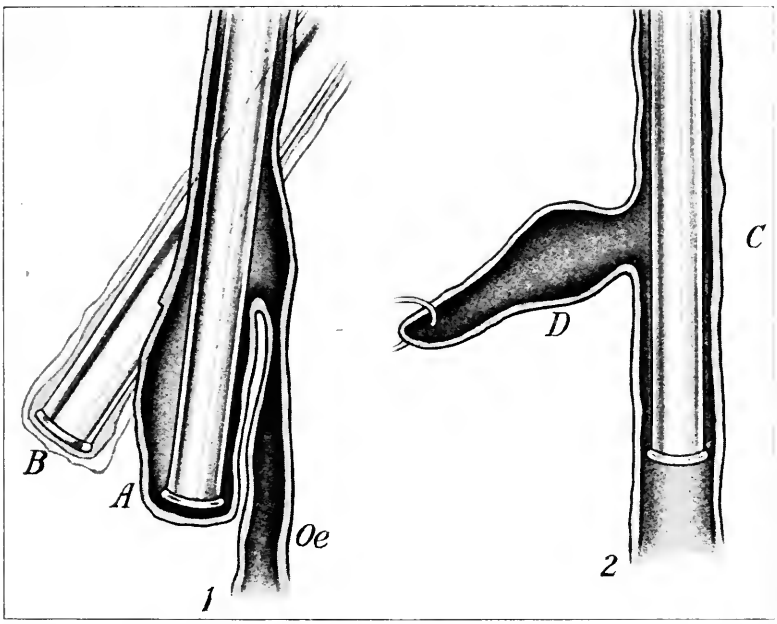


FIG. 41.—*1*, diagrammatic representation of esophagoscopic aid in the excision of a diverticulum (Gaub): *A*, esophagoscope in bottom of diverticulum; *B*, esophagoscopist lifts the dissected pouch toward the surgeon; *Oe*, esophagus. *2*, *C*, esophagoscope in lumen of esophagus indicating its normal size which must not be encroached upon by the operation when removing the sac; *D*, diverticulum put on stretch. (Chevalier Jackson.)

the stump; additional interrupted sutures of the muscular coat, in single or double layer, or, if a purse-string suture cannot be placed, closure of the muscular coat alone.

Should, however, the neck of the sac be wide and hypertrophied, in that event a mass ligature is strongly advised against. It might slip off before additional supporting stitches have been placed, and thus permit esophageal contents to escape. Under such circumstances it is better to cut the pouch off with scissors, flush with—or, somewhat in front of—the pharyngo-esophageal wall and suture the submucosa and muscularis in layers.

To pierce the basis of the diverticulum with needle and thread and then ligate, as is customary when dealing with a hernial sac, may do no harm, but is a less advisable procedure.

In the one-stage operation the posterior mediastinum is best drained by a gauze tampon plus cigarette drain, led out at the lower angle of the wound, while the upper portion of the latter is closed by sutures.

The postoperative course is usually satisfactory. When preliminary gastrostomy had been performed, a procedure which seems indicated in very reduced patients only—the gastric tube alone is used for feeding; otherwise rectal alimentation with hypodermoclyses and hypodermic stimulation are resorted to during the first two, three or four days after the operation. Generally speaking, the rules for the after-treatment of operations upon mouth and neck hold good.

If the sutures do not hold and a fistula develops, the patient's convalescence may be delayed, but the ultimate result will not be frustrated. These fistulas come to a close almost in every instance.

The risk of this operation is not great.

Of 60 cases radically operated upon in one stage by various surgeons, 50 recovered, being a mortality of 16.6 per cent., which, no doubt, will be greatly reduced in the future by avoiding excision of the sac or operating in two stages.[1]

Goldman[2] prefers a two-stage operation. He first isolates and ligates the neck of the sac, and, in the second stage, excises the sac. In this way technic of the operation and after-treatment are simplified.

Schmid[3] proposes turning the sac upward, instead of excising it, and stitching the fundus of the diverticulum to the wall of the pharynx above.

Murphy[4] preferred a two-stage operation in every case. During the first stage the sac is thoroughly freed, twisted and sutured in place; the wound is tamponed; twelve to fourteen days later, after granulations have formed, the sac is removed.

Bevan[5] recently also advised against removing the sac, and suggested infolding it by means of a series of purse-string sutures. The diverticulum is thus gradually turned into the lumen of the esophagus, where it either atrophies or is cast off.

Wherever this infolding operation can be performed, it must be considered the operation of choice on account of the elimination of infection. I recently had a very satisfactory result from this method in a case of medium-sized diverticulum with broad base and a retro-esophageal attachment. There was a slight temporary discharge of swallowed fluid from the lower angle of the wound, most likely in consequence of the suture having pierced or necrosed the very thin sac in one place; but the final result was excellent.

[1] Stetten, D.: Am. Surg., 1909, li, 300.
[2] Beitr. z. klin. Chir., 1909, lxi, 741; 1912, lxxviii, i, 139 (Geiges).
[3] Wien. klin. Wchnschr., 1912, No. 13, p. 487.
[4] Surg. Clinics of Chicago, 1916, v, 391.
[5] Ibid., 1917, i, 449.

The two-stage operation employed by C. H. Mayo[1] consists in dissecting the sac without opening it, leaving the neck attached; the wound in the patient's neck is then sutured, care being taken to fasten the skin edges to the esophagus at its juncture with the diverticulum; the sac is left outside of the neck, in the dressing. Ten to twelve days later, adhesions having formed about the sac, it can be removed without an anesthetic, and the edges be turned into the esophagus.

This method is particularly intended for use in cases having a fairly large sac. In a series of 35 cases operated upon at the Mayo Clinic, *i. e.*, excision with inversion of the base (18), excision with ligation and inversion of the base (4), infolding (3), two-stage operation (10), they had two deaths in old, feeble patients on the day following the operation. In 2 of the remaining cases there was some evidence of a recurrence of the diverticulum; in one of these the patient was entirely relieved by sounding; the other required a second operation. Almost all of the 33 patients could later be reached by letter and were found entirely free from symptoms.

The infolding operation of Bevan and the two-stage operation are considered the best procedures.

In view of our ability to definitely cure the patients of this distressing and dangerous condition, active therapy is clearly indicated in every instance. Should grave contra-indications in an individual case render the operation too risky, gastrostomy can still bring relief and lengthen life.

As to intrathoracic diverticulum, only one operation is so far on record. It was performed by Henschen[2] with the help of blocking with a 2 per cent. novocain solution the phrenic nerve and both pneumogastrics and resulted in the death of the patient. A large, supracardiac sac was found and excised and the esophageal wound carefully closed by three rows of layer-sutures. Leakage occurred on the fourth day after the operation and produced suppurative posterior mediastinitis, to which the patient succumbed.

Cicatricial Stenosis of the Esophagus.—The principal type of cicatricial stenosis, interesting us here, is the one due to an escharotic, a burn from caustic lye or acid (carbolic, sulphuric, etc.). The swallowing of caustic lye was a rather frequent occurrence among young children at the time when bathtubs were still lined with tin, and lye was generally used for cleansing; also in the times of home-made soap (Jackson). Today, with changed conditions of manufacture, these accidents are rarely met with. Pure acid is still occasionally swallowed by grown people, accidentally or with suicidal intent.

Some days after the accident the result of such a burn of the third degree manifests itself: the esophagus becomes gradually strictured, often in a number of places. If left to itself, all kinds of folds, bands, pockets and diverticula will form and produce a so-called impermeable cicatricial stricture.

[1] Judd, E. S.: Surg., Gynec. and Obstet., 1918, xxvii, 135–141.
[2] Centralbl. f. Chir., 1916, No. 21.

Treatment.—The development of the stricture can be prevented, if a trained esophagoscopist is promptly called in and, *under the guidance of the eye,* starts at once the introduction of proper bougies. But even after the development of the stricture an esophagoscopist should be consulted and given a chance to relieve the condition. His trained eye and quiet persistence—so absolutely needed for endoscopic examination in any part of the body—will in most instances find the entrance to the stricture and then direct a filiform bougie downward. This accomplished, progress will be made quickly. In the esophagoscopist's instrumentarium for this kind of work, Plummer's double olive bougie occupies a favorite place (Fig. 42). Bunt originally devised it for sounding by the sense of touch, not for the esophagoscopist. But it stands to reason that under the guidance of the eye this bougie can be handled more safely and to better advantage.

Others have used a stout catgut thread which, left in place, swells by the absorption of fluid and thus widens the stenosis.

FIG. 42.—Plummer's double olive bougie. (Jackson.)

A new "telescope" dilator has been constructed by Leiter, on basis of Lotheissen's[1] (Vienna) design. It is made of telescoping spiral metal bands; it is intended to act gradually, but sometimes does work rather rapidly. A dilator of this type of 5 mm. diameter corresponds to a No. 22 French scale, or an English bougie of medium caliber. With the latter, dilatation is then continued.

Another method which promises more rapid progress in the dilatation of permeable cicatricial stenoses is that of v. Hacker,[2] the so-called "endless sounding" ("Sondiren ohne Ende") by means of an ordinary rubber drainage tube. It is based on the experience that a rubber tube, introduced in an elongated condition into a stenosed part and then released, has the tendency to regain its normal caliber. In this way, it will gently, gradually and continually stretch the stenosis. By producing through this irritation local hyperemia, it will at the same time stimulate the absorption of infiltrations. Von Hacker has invented a special simple and effective manner of introducing the elastic tube, which is illustrated in Fig. 43. Should fever set in, pointing to overirritation (peri-esophagitis), the treatment must be temporarily interrupted. Preliminary gastrostomy, in difficult cases gastrostomy plus esophagostomy, is required. As soon as a silk thread has then been successfully passed from the gastric fistula through the stenosed esophagus up to and out of the mouth (see below) rubber drainage tubes of increasing caliber are pulled through—on the stretch—from below. The drainage tubes remain within the stricture

[1] Verhandl. d. deutsch. Gesellsch. f. Chir., 1914.
[2] Centralbl. f. Chir., 1894.

but a few hours. A silk thread, pulled through the stricture on removal of the tube, takes its place during the interval.

As soon as a sufficient lumen has been established in the stenosis, the ordinary flexible silk and wax bougie, or the olive, is used at regular intervals from above. If it passes readily, it is well to teach the patient to pass it himself regularly, once every week, and then gradually at longer intervals. One of the best additional dilators is the bolus of food.

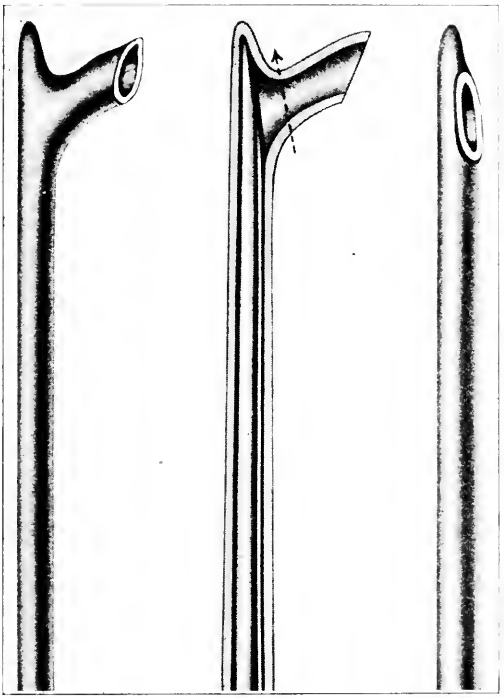


FIG. 43.—Drainage tube drawn out over mandrin for sounding and stretching the strictured esophagus. (von Hacker.)

A point that cannot be too strongly emphasized in all this certainly brilliant, often non-operative work is, that sounding a cicatricial stenosis, with or without the use of the esophagoscope, be carried out with *extreme gentleness*. Blunt poking is absolutely prohibited. Thereby a false passage or even a perforation may be easily made and may prove fatal. Particularly, if an esophagoscopist is not available and gastrostomy not permitted by the patient, must this rule be most rigidly adhered to. If an obstruction is met by the bougie, this must under no circumstances be forced, but another place tried, for the entrance to the stricture is rarely in the depth of a funnel; often diverticula have formed and a small hole close to the esophageal wall may be the continuation of the lumen. In such a condition von Hacker's method

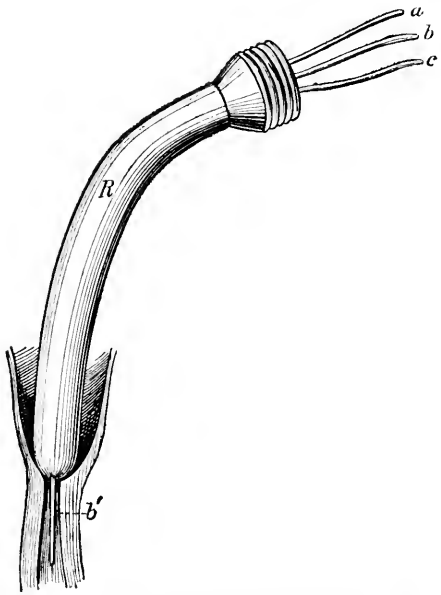


FIG. 44.—Von Hacker's method of introducing thin bougies (*a*, *b*, *c*) into the stricture (*b'*) through a wide hollow bougie (*R*). (Keen.)

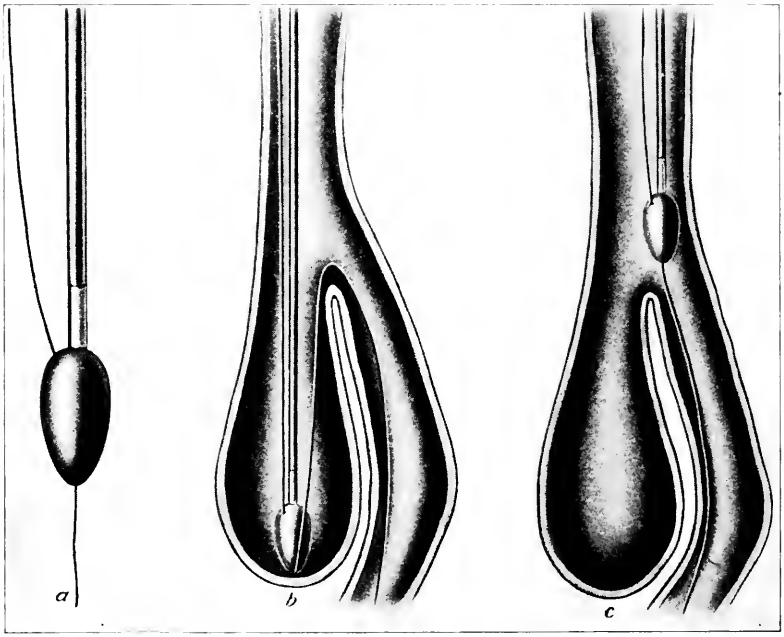


FIG. 45.—*a*, Plummer's olive-tip bougie with guide silk, threaded through the olive which is drilled in oblique direction; *b*, the same introduced on silk—the lower end of which has passed down the length of the duodenum—into a diverticulum; *c*, upper end of thread drawn taut—this manipulation lifts the olive and places it in front of the lumen of the esophagus, and by pushing it on, following the guide thread, it will enter the tube.

may be tried: a flexible bougie with central canal is introduced down to the obstruction and now a number of filiforms carefully tried one after the other (Fig. 44). If no progress is made, try Plummer's[1] ingenious method. He had the olive drilled obliquely from the tip to one side of the base (Fig. 45*a*), and threads a piece of buttonhole silk through this canal, about six yards of which had been swallowed one day before,[2] according to the method originally devised by Theodore Dunham[3] of New York. After the thread reaches the stomach, its distal end is gradually carried so far into the intestinal canal that an outward pull will not withdraw it. Now the olive-tipped bougie is introduced. Usually it will become engaged in the pouch above the stricture (Fig. 45*b*). If now the thread outside is drawn taut, the olive is pulled up and as a matter of necessity, its tip is placed in front of the stricture (Fig. 45*c*). By keeping the thread on the stretch with the left hand, the olive can then be safely and easily pushed forward; the thread will guide it down toward the stomach. After the first success, olives of larger caliber can be used. In case of tortuous strictures a spiral tip offers advantages (Fig. 45*d*).

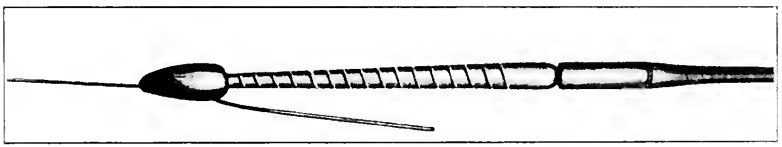


FIG. 45*d*.—Spiral tip, used in conjunction with the fenestrated olive, for the treatment of tortuous strictures.

Sippy, of Chicago, had manufactured a set of olives, 17 to 40 French, that are passed over a piano wire which is primarily introduced into the esophagus. This is done with the help of a silk thread previously washed down, and the obliquely drilled olive tip. The olives are passed with the aid of a special piano wire staff.

A very ingeniously worked-out new instrumentarium for the same purpose has recently been devised by Armistead C. Crump, of this city, and tested with success in a number of stricture cases. It is constructed on the principle of passing the stenosis "by twisting" a flexible piano wire with a very sensitive spiral tip. This wire is then used as a guide for the passage of dilating olives. The instrumentarium will be published in the near future. (Personal communication.)

All these methods start from the premise that the filiform bougie or the silk thread enters the stomach. If this cannot be accomplished, and if the esophagoscopist is unsuccessful or finds it impossible to

[1] Jour. Am. Med. Assn., August 15, 1908, p. 548.

[2] "It is advisable to have the patient swallow three yards in the afternoon and the remaining three yards on the following morning. In this manner the first portion forms a snarl in the esophagus, or stomach, which passes out into the intestine during the night, the remaining portion passing without snarling."

[3] Ann. Surg., 1901, xxxiv, 822.

make headway, and the patient gets tired and desires more radical work, then operative interference is indicated.

In this event the first step should be a gastrostomy, according to v. Hacker's, Witzel's, Kader's, or Senn's method.[1] The fistula having been firmly established and general nutrition improved, the second step is the passing of a silk thread 5 or 6 feet long (black) from the mouth into the stomach and out through the gastric fistula. As soon as this is accomplished, the battle is usually practically won.

The silk thread is best washed down into the stomach by making the patient drink it, holding one end at the mouth (Dunham). It is not always easy to pull the other end out of the gastric fistula. Repeatedly I have succeeded in getting hold of this end, by filling the stomach thoroughly with water by way of the gastric fistula. By pressure upon the abdominal wall the contents are then forced out and carry the thread along. Or, I have located an iron-dyed thread with the cystoscope that had been introduced into the stomach through the fistula and then grasped the thread with a slender curved dressing forceps under the guidance of the eye. I have also caught it blindly, making the thread (or filiform bougie) swim on top of the water in a half-filled stomach. As mentioned, Lotheissen, of Vienna, has simplified this part of the work by the use of thin spiral metal bands. One such, after thorough boiling, is gently passed into the stomach, where it is readily discovered with the fluoroscope. In front of the screen, its lower end is grasped and pulled out of the fistula. It then serves as guide for further manipulations.

Returning to the silk thread, once it has passed as a guide from mouth to gastric fistula, Abbe's string-method[2] is the operation of choice, and will, in most cases, be crowned with success. Using the silk thread as saw (see-sawing) (Fig. 46) Abbe cuts through the stricture from within and then dilates the lumen gradually by sounding. The thread will not cut the esophageal wall, but only the stricture, and that practically without hemorrhage. Years ago, I once used in a little girl of four years a urethrotome for this purpose, introducing it through an esophageal lip fistula at the neck, which had been established in addition to a gastrostomy. Acute, fatal meningitis was, in that case, the immediate consequence.

Theodore Dunham,[3] of New York, has given this subject much thought. He has designed an improved instrumentarium, the excellent working of which I have personally repeatedly had occasion to test. Dunham uses a fishline for cutting (Fig. 47). The stomach, inclusive

[1] Lotheissen (l. c.) warns against using too much stomach wall in these cases, when establishing the gastric fistula. He prefers the von Hacker-Lucke method, and selects a place in the anterior wall, *near the cardia*. Sometimes he has seen a seemingly impermeable stricture become permeable by virtue of the traction on the esophagus exerted by the presence of the gastric fistula made at this spot. Likely the straightening of kinks was responsible for such outcome. He further emphasizes the fact that a gastric fistula at this spot does not forestall the use of other parts of the stomach for plastic operations (Beck-Jianu—see below, under "Esophagoplasty") should the esophageal stricture be absolutely impermeable.

[2] Abbe, R.: New York Med. Record, 1893.

[3] Annals of Surg., 1901, l. c.

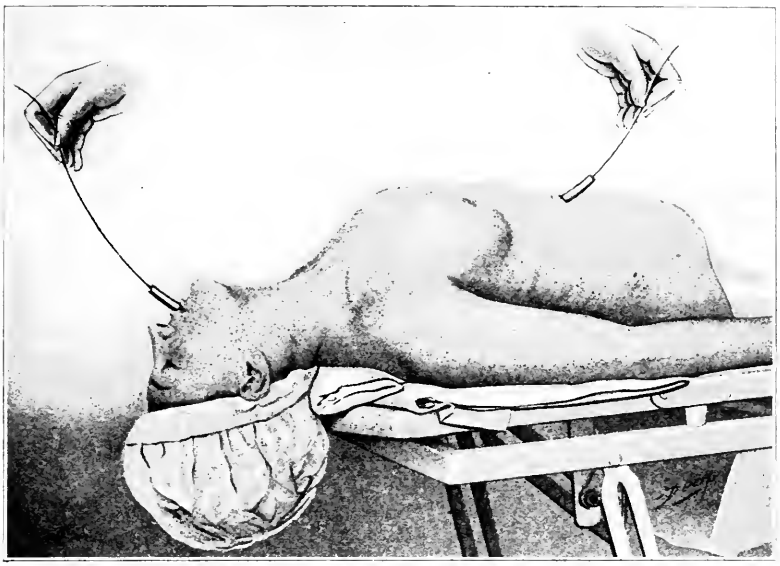


FIG. 46.—Abbe's string method, improved by Th. Dunham. Internal esophagotomy is performed by see-sawing a silk thread through the stricture. Guard tubes in place.

FIG. 47.—Fishline for internal esophagotomy according to Abbe. (Dunham.)

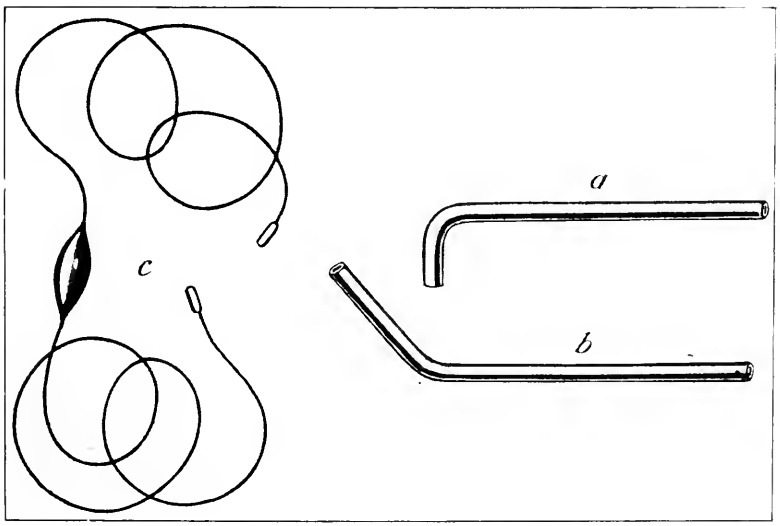


FIG. 48.—Theodore Dunham's instruments for the treatment of cicatricial stricture of the esophagus. *a*, guard tube for pharynx; *b*, guard tube for stomach; *c*, wire- and spindle-bougie.

of gastric fistula, the mouth and pharynx are protected by means of special, curved metal tubes, through the lumen of which the fishline runs (Fig. 48 *a* and *b*). At the spot where the cutting is to be done a metal olive on a wire guide is held in place by the fact that it refuses to pass the narrow gorge (Figs. 48*c* and 49). After thorough lavage of the stomach, everything is put in place, the patient being under general anesthesia. It is wise not to try to accomplish too much at one sitting, but to divide the work in two or three parts. The dividing and stretching must not go beyond No. 35 to 40 French gauge. Up to that time a silk thread always remains *in situ*. Its ends are fastened to the cheek or to the abdominal wall by means of adhesive plaster. The thread should never be drawn too taut. I have seen that, in one of my little patients, induce a lateral division of the canal of the gastric fistula which, later on, prevented the spontaneous closure of the canal. After the tube for feeding was permanently removed, it required a rather difficult excision of the fistula and closure of the hole in the stomach by stitches.

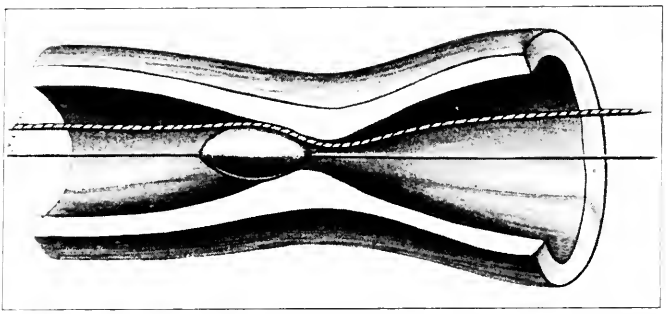


FIG. 49.—Dunham's wire-spindle bougie, wedged in stricture; next to it, fishline ready for pulling in order to divide the constricting cicatricial stenosis by see-sawing.

Abbe's method of operating should rather not be carried out in one sitting with the help of gastrotomy, the stomach then being sutured at the end of the operation. It is much safer to establish first a gastric fistula and then to use the same for operation as well as for feeding.

The final results of Abbe's operation are most gratifying and permanent. The daily descent of the food keeps the lumen patent. Now and then, best at regular intervals, the bougie must be brought into action. The dangers attaching to its use in the beginning are at this advanced stage of the treatment almost *nil*.

This procedure has to be considered the standard operative method. Its *conditio sine qua non* is

1. The permeability of the stricture.

2. The successful passage of the thread from the mouth through the gastric fistula.

It will often be found that an impermeable stricture becomes permeable after gastrostomy has been done and the continuous irritation of the stenosed canal by the food is temporarily done away with.

Permanently impermeable strictures are extremely rare. Among 253 cases of his own observation, Lotheissen found it once. In 1904 I have also had one of this kind (see further down).

In such cases, lest the patient be made to depend forever on his gastric fistula, are indicated:

1. Attempts at retrograde sounding.
2. The formation of an extrathoracic esophagus by plastic methods, extrathoracic esophagoplasty.

1. *Retrograde Sounding.*—This can be done

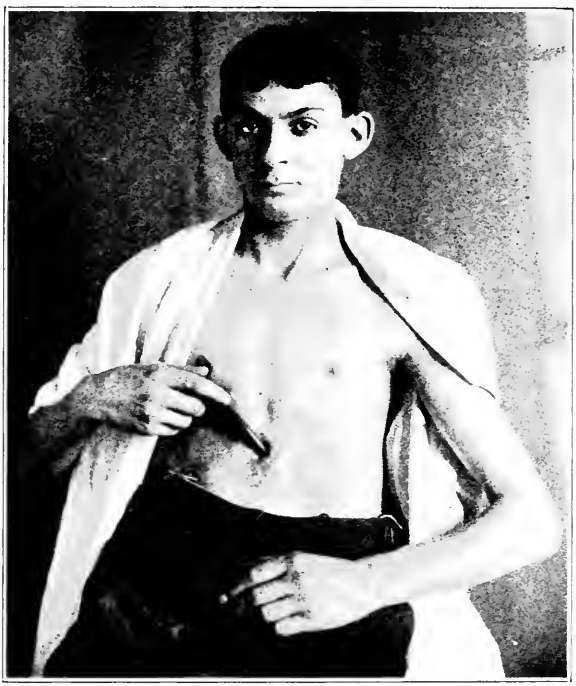


FIG. 50.—Gastrotomy with the help of an osteoplastic resection of the costal arch, in the presence of a gastric fistula, by means of a V-shaped incision for impermeable cicatricial stricture of the esophagus. Recovery. The illustration shows the patient four years after the operation.

(*a*) *Without Operation,* by introducing the ureter cystoscope, or, better, the esophagoscope through the gastric fistula, as far as the cardia, and then trying to pass a ureteral catheter or a filiform bougie upward. If successful, the silk thread will at once be drawn through.

(*b*) *With Operation.*—If unsuccessful, advance may still be tried by means of an operation.

By way of the abdomen: osteoplastic resection of the left costal arch with gastrotomy and retrograde sounding.

Personal observation:[1] Boy, aged fourteen years; had had to undergo

[1] Meyer, Willy: Jour. Am. Med. Assn., 1906, xlvii, 1069.

gastrostomy when six years old; for eight years feeding had been done through the gastric fistula. All attempts on the part of other surgeons, to pass the stricture had been futile. My efforts, too, were unsuccessful. I, therefore, established an esophageal lip-fistula at the neck, through which Kelly's urethral tubes were introduced, and then searched, under direct illumination for the entrance. The latter was found, but no definite progress could be made. It was also impossible to pass upward through the esophagus a ureter-catheter which had been introduced through the cardia with the help of a ureter cystoscope. At last, therefore, retrograde sounding by operation, viz., the osteoplastic resection of the left costal arch was attempted (1904) (Fig. 50). The stomach was exposed, longitudinally incised and the cardia entered. Bougies refused to pass upward, although I risked even direct divulsion with a long, slender forceps introduced through the cardia into the esophagus for quite some distance upward. All attempts to pass a bougie to the mouth failed. So this plan, too, had to be abandoned. The osteoplastic flap was put back and stitched in place. The wound healed kindly and the function of the gastric fistula was preserved. The proposed esophagoplasty according to Bircher's method (see page 129) was not accepted. The boy is still living and continues to nourish himself through the gastric fistula.

By Way of the Thorax. (H. Fischer[1]).—Three-year-old boy. Caustic lye burn. Almost completely impermeable cicatricial stricture. Gastrostomy, Lenox Hill Hospital, New York. Radiograph shows stricture from tracheal bifurcation down to a spot 2 cm. above diaphragm. Bismuth mixture which had passed through, makes this clearly visible. Attempt to wash a silk thread down is not successful, neither is retrograde catheterization by way of the gastrostomy opening. Thoracotomy under insufflation. Cardia exposed; peritoneal cavity entered from above and stomach pulled into thorax for about 7 cm. Careful tamponade. Transverse incision of cardiac portion about 3 cm. below union of esophagus and stomach, the latter having been secured with two loops of silk thread. Now a ureter catheter with mandrin slips easily upward. A dressing forceps which is passed from the gastrostomy opening through the cut near the cardia grasps the other end of the ureter catheter and conducts it out of the gastric fistula. A double row of sutures closes the incision in the wall of the stomach. The latter is then replaced, the cardia sutured to the diaphragm and the thorax closed.

The boy died twenty-four hours later from acute congestion of the lungs, due to a mistake at the hands of the anesthetist who, by opening the wrong valve, had blown minute particles of ether into the lungs.

2. *Extrathoracic Esophagoplasty.*—It is in these cases of impermeable stenosis, that surgeons have succeeded by most ingenious plastic surgery, done in a series of operations, in forming a new tube extrathoracically: partial or total esophagoplasty. The operation has

[1] Centralbl. f. Chir., 1910, No. 43, p. 1393.

proved to be feasible in various ways, with an absolutely lasting and favorable functional result. (See under "Esophagoplasty," page 128.)

Chronic ulcerations, the forerunners of cicatricial contraction other than escharotic stenosis, such as traumatic, tuberculous, syphilitic, have been mentioned above. The history of the case and the many means at present at our disposal for a refined diagnosis will usually suffice to clear up the true characteristics of the trouble, *before* an operation is undertaken.

Stenosis Due to Tumor Formation in the Esophageal Wall.—The most frequent cause for the formation of a stenosis of the esophagus is a growth in its wall. This may be either benign or malignant.

Strictures Due to a Benign Tumor.—In comparison with strictures resulting from malignant tumors, these are rare cases. Nevertheless, they are more frequent than is generally believed. They do not produce a stricture in a pathological sense, but clinically, in that they cause increasing difficulty in swallowing. As a rule it is not until the tumor has reached considerable size that the patient's attention is drawn to it by the resultant difficulty in deglutition. But even when still of small dimensions, a benign tumor is accompanied by inconveniences which make themselves felt at all meals. The family physician who will probably be first consulted, is apt to make light of the patient's complaints, ascribing them perhaps to some general nervous affection, *e. g.*, neurasthenia. It is necessary that, in the face of such complaints, esophagoscopy should more frequently enter the physician's mind and become as generally recognized for purposes of examination as cystoscopy, rectoscopy, etc., have become in the course of recent years.

All classes of benign tumors connected with the "make-up" tissues of the esophageal wall, as papilloma, fibroma, myoma, adenoma, lipoma, angioma and their manifold combinations, have been observed. Missing infiltration at the base, and pedunculation characterize the nature of the growth. In cases of doubt regarding the nature of the tumor a specimen should be punched out for microscopic examination. The slight hemorrhage sometimes following, will yield to the swallowing of ice pills or ice-cream.

A benign tumor ought to be removed, as it might turn into a malignant one. If at all possible, the operation should be done endoscopically. In removing the tumor the base should be carefully treated by biting it out with proper forceps and cauterizing it with the galvanocaustic wire, provided hemorrhage does not forbid this. The primary use of the galvanocaustic wire or snare would appear to be best. Its application must depend upon the peculiarities of the case and the dexterity of the operator. At all events, these tumors need careful attendance, as many of them have a tendency to recur, same as those of the larynx or bladder.

Strictures Due to the Presence of a Malignant Tumor: Sarcoma and Cancer of the Esophagus.—(*a*) SARCOMA.—Regarding this type of

malignant neoplasm, von Hacker[1] has made an exhaustive study covering 21 cases described in the literature. One of these, presenting a sessile tumor in the cervical portion, came under his personal care. Esophagoscopical probatory excision of the tumor enabled him to make the correct diagnosis. The cervical segment of the esophagus was resected.

Sarcoma may appear pedunculated (polypoid) or sessile, with diffuse infiltration of the wall of the tube. It has a great tendency to show degenerative changes with subsequent necrosis and ulceration. Nineteen per cent. of the cases were found in the cervical, 81 per cent. in the thoracic portion.

(*b*) CANCER.—*Occurrence.*—Cancer of the esophagus, same as cancer in other parts of the gastro-intestinal tract, has a decided predilection for physiological stenoses. The manifold lesions to which the tube is constantly subjected by the ever-recurring descent of the food, no doubt favor in patients predisposed to cancer the development of the tumor at these spots. An old syphilitic or tuberculous ulceration or scar may also furnish the starting-point for a malignant growth.

In accordance with the aforesaid predilection we find cancer of the esophagus most frequently:

1. Near the very beginning of the esophagus, behind the cricoid cartilage at the neck.
2. Behind the bifurcation of the trachea.
3. At the hiatus esophageus of the diaphragm.
4. At the cardia.

From a pathological point of view it may be correct to differentiate as stated under 3 and 4; clinically the last two types are to be combined under one head, *i. e.*, cancer of the cardia (von Hacker).

Expressed in percentages and round figures the frequency of cancer of the esophagus with reference to the above sites, is approximately as follows: Neck, 10 per cent.; bifurcation, 40 per cent.; hiatus, 28 per cent.; cardia, 22 per cent.; or the latter two combined and grouped under the common head of "Cancer of the Cardia," 50 per cent., or one-half of the cases. By adding the malignant tumors of the lesser curvature, near the cardia, which clearly belong to this group, at least from an operative point of view, it will become evident that cancer of the cardia is not a particularly rare disease. Cancer of the esophagus takes the fifth place in the total frequency of all carcinomas.

Type of Tumor.—The most common variety, pathologically, is the squamous-celled epithelioma (or endothelioma); the other type is the cylinder-celled carcinoma which takes its origin in the atypical proliferation of the cylindrical epithelial cells of the mucous glands within the esophageal wall. The former is the more benign of the two. The growth of a neoplasm of the esophagus is similar to that of a cancer of the rectum. At first it remains localized in one small place of the tube; gradually it infiltrates the submucosa and muscularis and sur-

[1] Mitt. a. d. Grenzgeb., 1904, No. 3, vol. xix.

rounds the canal in the shape of an irregular crescent. At this time the previously noted inconvenience in swallowing will give way to signs of stricture. The infiltrated ring having become complete, only fluids now pass down. Constriction and swelling continue to increase, until finally total occlusion sets in. Ulceration of the surface appears comparatively early, probably as a result of the ever-repeated irritation caused by the bolus in its passage through the constricted canal.

There is one important characteristic of cancer of the esophagus that should be especially emphasized, namely, that it is the most benign of all carcinomas of the gastro-intestinal tract. Its growth is comparatively slow; it remains localized for a long time; has little tendency to metastasis in other parts of the body, or in the lymphatic glands, and is not very apt to recur.

Symptoms.—As regards clinical symptoms, the first trouble complained of by a patient afflicted with esophageal carcinoma, is difficulty in deglutition. He has as yet no pain; that begins later. The necessity of pressing a morsel down by means of holding his breath and then exerting intrathoracic downward pressure, or of washing the bolus down with a swallow of liquid, first attracts the patient's attention and induces him to consult a physician. Let the latter then remember, have him know, that such complaints should not be lightly treated; a pill or a powder is here of no avail. Our undergraduate and post-graduate students should be taught and should have it impressed upon their minds, that such a case needs the same prompt attention that would be given to a case of acute appendicitis. Of course, it is not a question of immediate operation, as in that case, but of bringing into play promptly all the modern means for an exact diagnosis. How to use these means has been dwelt upon at length above, under "Examination of the Esophagus."[1] Let it be remembered and said again and again, that a plainly present stenosis, unless resulting from the swallowing of a chemical, is in at least 80 to 90 per cent. of patients above twenty years of age, due to a malignant tumor. This, really, is *the* important point. Upon its general promulgation among medical students and practitioners as well as among the laity, hinges the possibility of progress that can and ought to be made in the resection of the esophagus for carcinoma. Let us always keep in mind that carcinoma of the esophagus, same as of other sites, is originally an entirely localized disease, that neighboring organs—nervi vagi, bronchus, aorta, lungs—are not involved until in a later stage and can therefore, with care and anatomical knowledge, be stripped off without serious injury. During the early period of the disease surgical interference is apt to effect a cure. Without operation, on the other hand, with internal medication,

[1] Not long ago my attention was called to an interesting and, it seems, valuable syndrome of clinical symptoms in *the early stage* of esophageal carcinoma, viz.: no difficulty in swallowing, pain immediately after swallowing, achlorhydria, negative radiogram. If these symptoms are found, the suspicion of the presence of a beginning malignant disease of the esophagus should be aroused. Fluoroscopy, x-ray pictures with a sausage skin bougie, sounding and esophagoscopy would establish the diagnosis. (Crump, 4 cases; personal communication; 1920.)

of one hundred patients afflicted with cancer of the esophagus, one hundred die of the disease, and death in every one of them occurs only after a long, protracted period of unspeakable suffering and misery. Certainly, the necessity of a full understanding all around of the importance of a spontaneously occurring difficulty in swallowing, cannot be too strongly emphasized.

As stated above, cancer of the esophagus is the most benign neoplasm in the entire gastro-intestinal tract. However, the continuous chemical and mechanical irritation due to the passage of the food over its surface, as also the comparatively small caliber of the tube and its extreme thinness (in man) make the early involvement of the main adjacent vital structures unavoidable. Thus the pneumogastric nerves from the aorta down will be found firmly attached to the tumor rather early. The growth will become adherent to, and soon involve, larynx, bronchi, pleura, lung, aorta and neighboring smaller bloodvessels and nerves. If left to itself, it will begin to ulcerate and then either perforate into the pleura, pericardium, the bronchial system, aorta, or it will continue its growth into the posterior mediastinum. Of course, such a breaking down of a constricting tumor will do away with the stricture. The patient feels happy, as he is again able to swallow. But such happiness is illusory and of very brief duration. The terrific *fætor ex ore* in such cases, that yields to no remedy, tells the tale, often to the poor sufferer himself, and the perforation of the wall will soon end his misery. Truly, the picture of a cancerous stenosis of the esophagus, if left unattended, or if treated symptomatically, cannot be painted in colors too dark. Every physician, who has once treated such a patient to the very end, will admit that.

Treatment.—In view of the foregoing, the necessity for continued endeavor on the part of surgeons to bring the treatment of esophageal carcinoma more generally within the domain of operative surgery, must be conceded.

In the early days of such endeavors seemingly insuperable difficulties presented themselves. All who worked along these lines were at first necessarily mere tyros in this particular work, and unwittingly dared much more here, than their experience in abdominal surgery would have prompted them to do in the abdomen under similar conditions. However, persistent and hard effort succeeded in overcoming one obstacle after another, so that today we are in a position to meet the dangers without trepidation. We know now proper operative methods for every section of the esophagus, and for every one of them a successful operation for carcinoma is on record.

Let us remember that this new field has only just been opened up. We are still standing on its very threshold. Let us remember how many years it has taken to bring abdominal surgery to its present high standard, how many thousands of surgical minds and hands have worked together, in combination with laboratories, to improve and extend its possibilities.

Non-operative Treatment.—There is not much to be said about non-operative treatment, most of which is of little or no avail and should come into consideration only if operation is refused or contra-indicated. Sounding, still favored by many, even in the earlier stage of the trouble, should, in my opinion, be definitely discarded. Nothing irritates and, in the end, incites to more rapid growth of the carcinoma in all directions, than sounding. A constricting tumor that has been subjected to dilatation with sounds, had better not be attacked surgically. Nowhere are the adhesions firmer and more extensive.

I am also opposed to the excision of a piece of the cancer by the endoscopist for microscopic examination. I have repeatedly observed pronounced aggravation of the patient's subjective symptoms, even prolonged fever, which delayed the urgent operation and perhaps contributed to jeopardizing its result.

The many obtainable symptoms and the positive knowledge that at least 90 per cent. of the spontaneously occurring strictures in patients above the twentieth year are cancerous, permit us to make the diagnosis without microscopical corroboration. Probatory excision before operation is looked upon with suspicion and disfavor by surgeons and cancer experts also in other parts of the body.

Every kind of intra-esophageal manipulation, such as instrumental stretching of the stricture, or this excision of a piece of tumor for microscopical examination, is bound to injure the esophageal wall and —from an operative point of view—should be condemned.

As regards the hopelessness of all remedies and methods of palliative treatment in these cases there is one exception that deserves further faithful experimentation: radium. Dr. Max Einhorn,[1] of New York, was the first to suggest its possible usefulness in this class of cases. At present there are many at work testing the efficiency of radium in malignant esophageal affections. It would be gratifying to find them obtaining favorable results. It is conceivable that a certain percentage of very early cases of cancer of the esophagus or cardia could be benefited by intra-esophageal treatment with radium. The majority of these tumors are of the squamous-celled type, which corresponds to the epithelioma of the skin, which latter, in many instances, yields to radium. Of course, the esophagoscopist should always corroborate by local inspection any apparent change for the better. Clinically the improvement will manifest itself by the returning ability to swallow. Personally, I expect to see *radical cures* achieved in very few cases, and fear that by such attempts the best time for operation will often be lost. Furthermore, the possibility of a perforation by a radium burn must not be overlooked.

So far there are only a very few cases on record in which an esophageal malignant tumor was permanently benefited by radium. N. S. Finzi[2] reports a case of an extensive ulcerating carcinoma three inches long in the lower part of the esophagus, well three years after.

[1] Med. Rec., March, 1904; Jour. Am. Med. Assn., July, 1905, p. 1434.
[2] Radium Therapeutics, London, 1913.

A second case became so well, that the patient refused to come for further treatment. Four years later, however, he returned to the hospital and died of a recurrence in the mediastinal glands.

Of 35 patients with cancer of the esophagus, under the care of J. Guisez[1] 1 case was well over two years at the time of the report, 1 one and a half and a third case over one year. In every one of the three cases the diagnosis had been confirmed by microscopic section.

H. H. Janeway, of New York City, has two patients who, he thinks, can be classed as complete retrogression. In both cases, however, the diagnosis was entirely clinical, and made by direct observation under the esophagoscope. The first case has remained well four years, the other a little less than a year. Both cases had favorable lesions at the start. (Personal communication, December 13, 1919).

Until more positive results can be shown from the use of radium, it remains our plain duty, it seems to me, to consider *all* these cases—from a general surgical point of view—operative cases, and that at the earliest possible date, for we know today how best to proceed, we know a reliable after-treatment and are fast learning to avoid complications in the course of the latter.

A number of cases of intrathoracic operation for esophageal carcinoma are recorded in the literature, with immediate operative recovery.

It is definitely to be expected that a steadily increasing number of patients will be seen to recover from esophageal resection, provided they come for operation in time: *in the early stage of the disease.*

Only those whose disease is either too far advanced to justify surgical interference, or who refuse radical operation, should be left to the treatment with radium rays.

The cylinder-celled carcinoma which takes its origin from the epithelial cells of the mucous glands of the esophagus and often involves several inches of the tube would probably yield to radium in exceptional instances only, and had, therefore, best remain definitely and wholly within the domain of operative surgery.

What is necessary is *confidence* in the present possibilities of operative surgery on the part of the medical profession as well as the laity. To gain this confidence a "series" of recoveries from operation is absolutely required. But how can a series of favorable operative results be obtained, if patients with cancer of the esophagus are usually referred to the surgeon for operation as a last resort only?

Operative Treatment.—This may be radical or for temporary relief.

1. *Radical Treatment,* viz., *Resection of the Esophagus.*

The procedure differs with reference to the location of the tumor, *i. e.,* whether it be situated—

(*a*) At the neck.

(*b*) Within the thorax. (Figs. 22, 51, and 52.)

(*c*) At the cardia.

It is necessary to discuss the operation from the standpoint of such subdivision.

[1] Strahlen-Therapie, 1914, iv, 44.

(*a*) *Resection of the Esophagus for Malignant Tumor in its Cervical Portion.*—Here again important differences exist, namely, whether the case in question be one in the early or advanced stage of the disease. In the latter instance, the infiltrated tube has become inseparably adherent to the larynx, so that the simultaneous extirpation of esophagus and larynx is the only alternative.

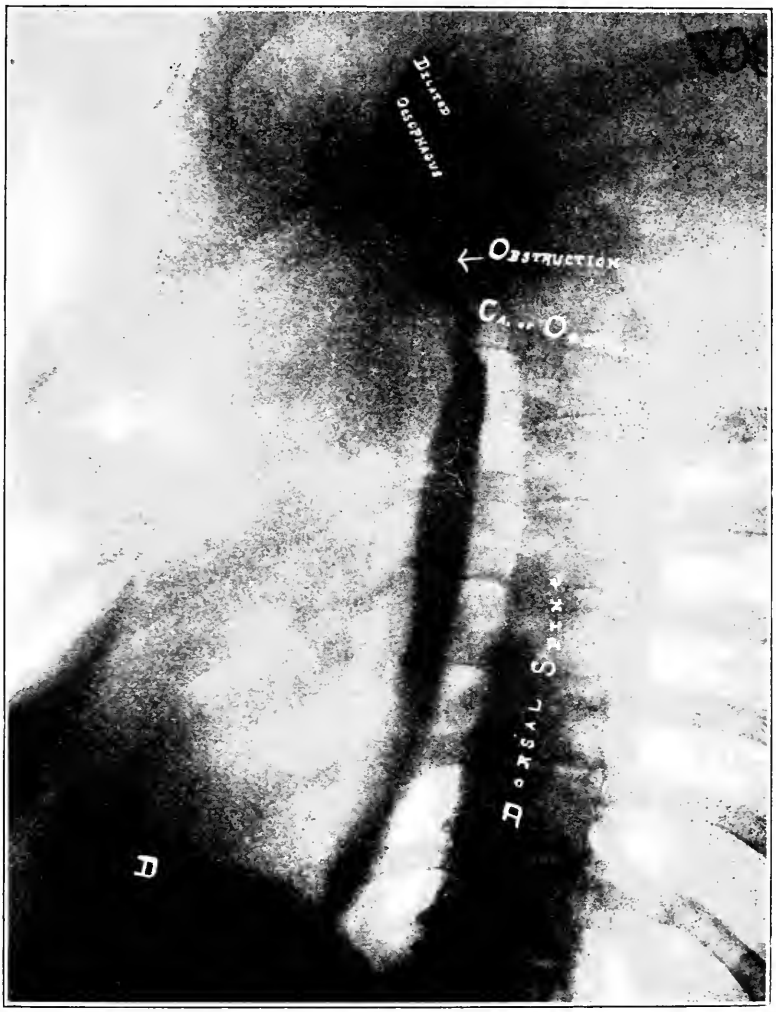


FIG. 51.—Carcinoma of the esophagus in its upper third.

1. *Early Cases.*—The operation is planned with a view to immediate restoration of the excised portion of the esophagus: partial esophagoplasty. Preliminary gastrostomy; rectangular flap incision best formed on left side of neck; exposure of cervical esophagus; dissection of infiltrated lymph nodes (superior and inferior cervical

group) along the deep jugular vein and in the supraclavicular fossa; careful loosening of the esophagus, particularly from larynx and trachea, saving the recurrent laryngeal nerve. Transverse amputation: amputation of the esophagus above and below the tumor at least 2 cm. ($\frac{3}{4}$ inch) from its edges. The superior circular cut may have to be passed through the pharynx. The posterior circumference of the upper and of the lower portion of the preserved tube is stitched to the skin flap. The latter is made to cover the depth of the wound, its raw surface coming in direct contact with the retropharyngeal or retro-esophageal loose connective tissue (Fig.

Fig. 52.—Total obstruction of esophagus in its lower third due to carcinoma.

53) while its free edge is turned back upon itself (Fig. 54). The skin-flap is thus converted into a tube of skin, lined with epidermis throughout. The interrupted stitches are then continued around the right lateral and anterior circumference of the two tubes. The free edge of the flap remains unsutured, because the base which nourishes the flap must not be disturbed. At this place the wound is tamponed. Ten to fourteen days later, the base may be safely divided and, after freshening of the edge, stitched to the latter. This completes the esophagoplasty. The defect on the right side of the neck is left to close by granulation or else is closed by plasty or graft.

2. *Advanced Cases.*—Simultaneous excision of cancerous esophagus with larynx and part of trachea. This is done in stages (von Hacker's method) after preliminary gastrostomy.

First Stage.—Same kind of flap formation, as under (1), but with the base of the flap formed on the right side of the neck; removal of infiltrated glands; extirpation of tumor-bearing portion of esophagus with attached larynx and part of trachea, in one mass. Tracheal stump is

FIG. 53.—Cervical esophagoplasty, first stage, diagrammatic; rectangular skin flap with base on right side of neck; cervical portion of esophagus with larynx totally excised; tracheal stump (*T*) as well as the transverse section of the esophagus (*Oe*) and pharynx (*Ph*) in line with skin. The raised skin flap covers original retropharyngeal space; part of its upper and lower border respectively, is stitched to the posterior circumference of the pharyngeal and esophageal cut surfaces.

stitched in place (Fig. 53). The formerly raised skin-flap is turned back; it covers the entire wound; part of its upper and lower edge is stitched to the posterior circumference of the pharynx above and to the esophagus below.

Second Stage.—Esophagoplasty.—Skin-flaps are raised on either side of the median line; their free, perpendicular edges are united with each other (Fig. 54). The horizontal edge is stitched to the anterior circumference of the tube above and below (Fig. 55). A larger skin-

flap on the right side of the neck is mobilized and pulled over to the left, thus covering the new part of the esophagus. Its border is sutured to the sternocleido muscle and a part of its lower end to the posterior half of the freshened trachea. The perpendicular skin wound to the left (Fig. 55) is likewise stitched to the esophagus.

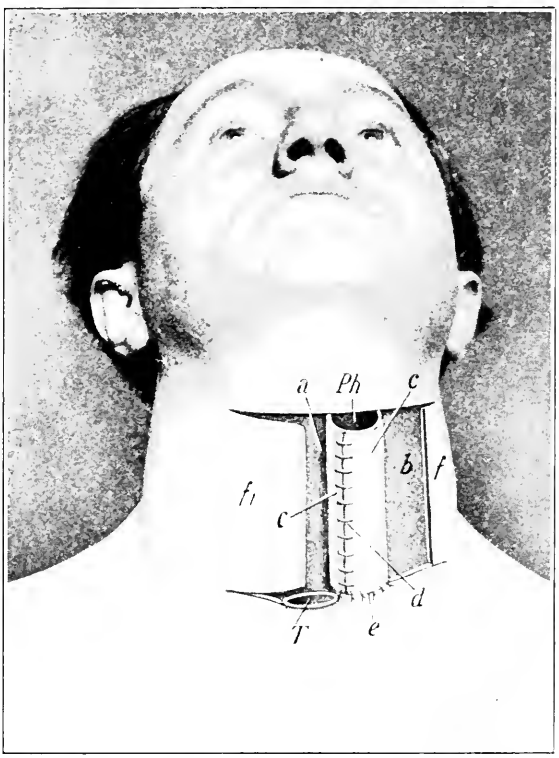


FIG. 54.—Cervical esophagoplasty; first phase of the second stage, diagrammatic. *a* and *b*, wounds after raising of skin flap; *c*, *c*, wound surfaces of the two skin flaps which have been joined to form new tube, their epidermal surfaces pointing inward; *d*, suture line of same; *e*, sutures uniting the lower edge of the flaps with the anterior circumference of the lumen of the amputated esophagus; *f* and f_1, lateral skin flaps dissected for use in the second phase of the operation; *T*, trachea; *Ph*, anterior circumference of unclosed upper end of the new-formed skin tube, the posterior wall of which passes over into the posterior pharyngeal wall.

In the majority of the patients operated upon, the disease had reached a far-advanced stage. The mortality was therefore high, 36 per cent. (v. Hacker), and recurrence was uniformly observed. Only one case (v. Hacker) had no recurrence at the time of the report, eighteen months after operation.

Improvement of these statistics will depend on earlier operation. The mechanical part of the operation certainly is nicely feasible and has been thoroughly worked out.

(*b*) *Resection of the Esophagus for Carcinoma in its Thoracic Portion.*[1]—No matter in what section of the tube the tumor is found, operation is always indicated.

Necessity of Preliminary Discussion with the Patient's Family.—At least one responsible member of the patient's family must be made fully acquainted with the seriousness and plan of the operation, particularly also with reference to the outlook for future deglutition; the necessity of forming a new esophagus, perhaps also of wearing a con-

FIG. 55.—Cervical esophagoplasty, second phase of second stage, diagrammatic. *f1*, larger rectangular flap with base on right side of neck pulled over the new tube, its border stitched to the sternocleido muscle; *f*, skin flap on left side of neck; its edge also stitched to the sternocleido muscle; *T*, trachea; *Ph*, entrance to the pharynx, upper end of new skin tube not yet stitched to skin in its anterior circumference; *h*, lower border of skin flap stitched to trachea; *i*, stitches which cover suture line of skin tube with esophageal mucosa. (Illustrations 53, 54 and 55 enlarged after v. Hacker.)

necting tube between the gastric fistula and the lower end of the transposed esophagus, etc.; the possibility of inoperability, appearing in the course of the operation, must also be emphasized in the discussion.

Contra-indication.—In patients who have been incapable of swallowing *solid* food for five months, six months, or longer, it may be assumed, that the originally unilateral growth has completely encircled the esophagus, and that the cancer is inoperable. The same is true of

[1] The present status of the operation is here outlined; its evolution has been omitted.

patients in whom the stricture has been subjected to regular dilatation with sounds. Nor does it seem wise to attempt radical work in patients in whom a portion of the esophagus, several inches in length, is involved, and symptoms of stricture had existed for five to six months. In two such cases the tumor was loosened by the writer from the adherent descending aorta, the opposite pleural cavity having first been opened and both adherent pneumogastrics divided below the aortic arch—steps that were tolerated without serious symptoms. Having successfully accomplished all that, the tumor was found deep down toward the right side, to have broken through the wall of the esophagus, diffusely infiltrating the posterior mediastinum. The azygos vein was tightly adherent to the growth, necessitating division and ligation in both instances, not to speak of the danger of injuring the thoracic duct. Besides, the difficult mechanical work that has to be done behind the aortic arch, where the sympathetics and vagi send their important branches to heart and lungs, usually causes such a severe drop in blood-pressure, that none of the many means at our disposal—chemical or physical—appear capable of restoring it sufficiently to prevent the patient's death during or soon after the operation.

These advanced cases should, therefore, not be attacked radically. Forcing the risks of such work in this class of patients will not help, but harm the advance of the surgery of the esophagus. What we may do, to gratify the patient's fervent desire to regain the ability of swallowing, is an operation for temporary relief. (See "Palliative Operation," page 117.)

Favorable Cases.—The most favorable cases for operation are circumscribed new growths of the squamous-celled type, occupying the portion between the aortic arch and the cardia, particularly if seen at an early stage. But even should the upper end of the tumor reach up to, or pass behind, the aortic arch, the outlook would still be sufficiently good to justify the attempt at resection, provided far-reaching infiltration at this point is still absent.

Operation.—There are two routes of advance upon a tumor of the esophagus, through the posterior mediastinum and the transthoracic route.

Posterior mediastinotomy has been advocated, because opening of the pleura can in this way be avoided. But, the field of operation is almost 10 to 15 cm. below the surface of the skin. The view is obstructed and free access to and exposure of vital parts is difficult (Fig. 56).

The transpleural advance, on the other hand, gives absolute control of the situation and enables the surgeon to properly cope with emergencies that may arise. However, the sequelæ to prolonged mechanical work within the pleural cavity have to be met. Personally, I prefer the transthoracic route.

On basis of universal experience, and the results so far obtained here and abroad, the following course of operation would seem to promise success:

1. Preliminary gastrostomy.
2. Transthoracic exposure of the tumor; resection; inversion of the distal esophageal stump; removal of the proximal stump from the posterior mediastinum; transposition of the same under the skin of the thorax anteriorly and downward. (Partial superior esophagoplasty.)
3. Closure of the thorax, with provision for airtight drainage.

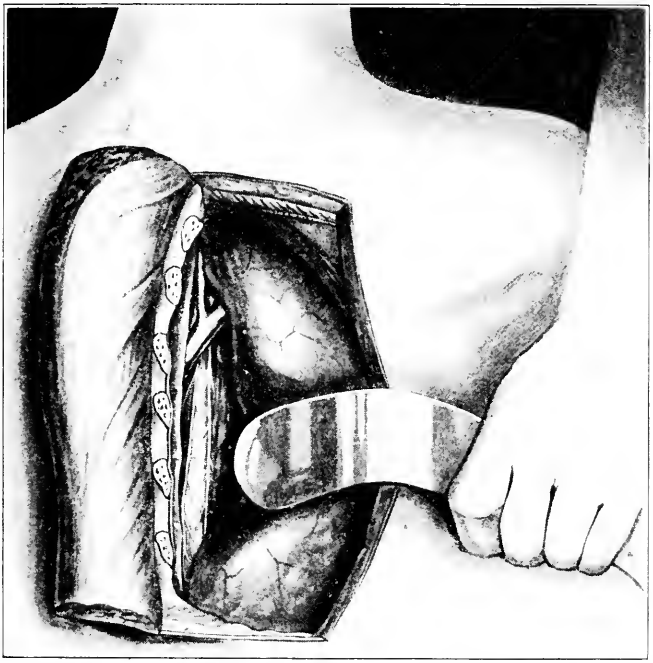


FIG. 56.—Posterior mediastinotomy (Enderlen). In the depth appears the thoracic portion of the esophagus.

Preliminary Gastrostomy.—To the well-known older methods of forming a water-tight gastric fistula, von Hacker, Witzel, Kader, Senn, and the one lately published by Janeway, a new one has been added in the course of the last years: the Beck-Jianu method, a gastrostomy which combines the establishment of a gastric fistula with the formation of a partly or almost complete new antethoracic esophagus, *i. e.*, "inferior esophagoplasty" (see below, under this caption). When doing gastrostomy, the foundation can well be laid for later esophagoplasty. The Beck-Jianu fistula is indicated when on palpation under the diaphragm, the cardia and its neighboring lymphatic glands are found free from disease, the stomach not unduly contracted and the patient's general condition favorable.

Technic of Operation. *Preparation of the Patient.*—The usual evacuation of bowels; irrigation of stomach through gastric tube until the

water returns clear; removal of tube, blocking fistula with iodoform gauze which is covered over with sterilized zinc adhesive plaster; iodinization of the same. One hour before beginning the operation, a hypodermic of $\frac{1}{4}$ grain of morphin + $\frac{1}{100}$ grain of atropin is given. The latter reduces the irritability of the nervus vagus.

Preparation for Operation.—Arrangement for differential pressure is indispensable, as both pleural cavities may have to be opened in the course of the operation, an emergency which does not seem to materially increase the seriousness of the operation, so long as a reliable method of applying the differential pressure, and of subsequent drainage of the pleural cavity have been provided for.

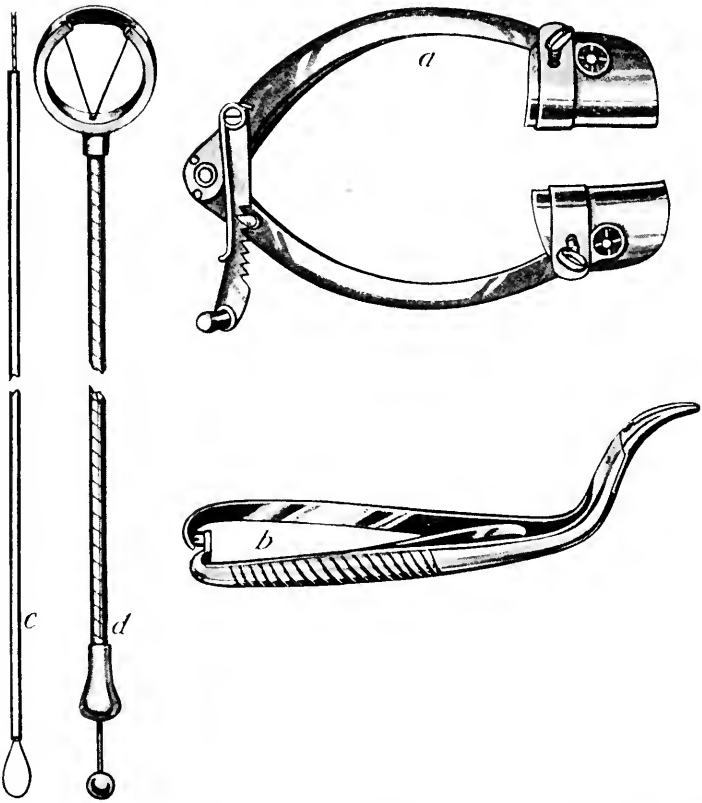


FIG. 57.—Special instruments for esophageal surgery. *a*, Friedrich's rib-spreader; *b*, needle-holder (Küster's swan); *c*, Ach's esophageal extractor (wire); *d*, Willy Meyer's esophageal extractor, (flexible metal bougie).

The most convenient form of differential pressure in these cases is intratracheal (or intrapharyngeal) insufflation, or the mask method. The presence of the rubber collar in the negative chamber or positive cabinet interferes in these cases with the maintenance of asepsis when operating at the neck for transposition of the proximal stump of the esophagus.

It has not yet been definitely determined which type of differential pressure is the safest for the patient in cases in which *both* pleural cavities have been opened in the course of the resection of the tumor. It is possible that the negative pressure method offers the patient the best chance. An attachment has been discussed to the present negative chamber as now installed at the Lenox Hill Hospital, on basis of the Swedish chamber[1] in which the mask is used in combination with negative pressure, an arrangement which would bring the head away from the apparatus and thus insure perfect asepsis also in esophageal work.

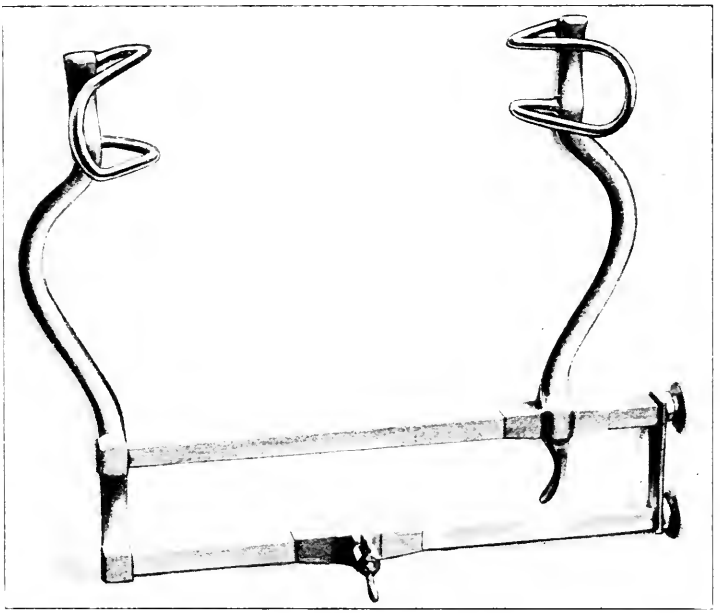


FIG. 58.—Balfour-Gosset retractor.

Instruments.—The instrumentarium should be as nearly as possible the same we use in our everyday work. A few additional instruments come handy: a reliable rib-spreader;[2] a needle-holder which facilitates the placing of sutures deep down ("Küster's swan" will be found handy in addition to the ordinary ones) and an esophageal extractor (Fig. 57).

Posture of the Patient.—A right latero-abdominal posture is required for a left-sided incision, and *vice versa* (Fig. 59).

At the thoracic department of the Lenox Hill Hospital of New York, a table of special design is made use of.[3] The illustrations

[1] Giertz, K. H.: Umea, Sweden. D. Z. f. Chir., 1913, cxxvi; C. f. Chir., 1914, 36, and several Swedish publications by the same author of 1913, 1914 and 1916.

[2] Here the abdominal one, known as the Balfour-Gosset retractor (Fig. 58) has given satisfactory results; those of v. Mieuliez and Friedrich are also recommendable. Lately one has been constructed by Lilienthal.

[3] It is manufactured by the Kny-Scheerer Co., of New York.

(Figs. 59 and 60) show its special points: the possibility of changing the height of the entire table; the chest-lifter, similar to the arrangement we have for kidney- and gall-bladder operations; removable head- and leg-supports; a special, perpendicular frame, which slides lengthwise on the table and buttresses the legs of the patient after they have been padded and bent at the knee at right angles, an arrangement that holds the patient immovably on his side.

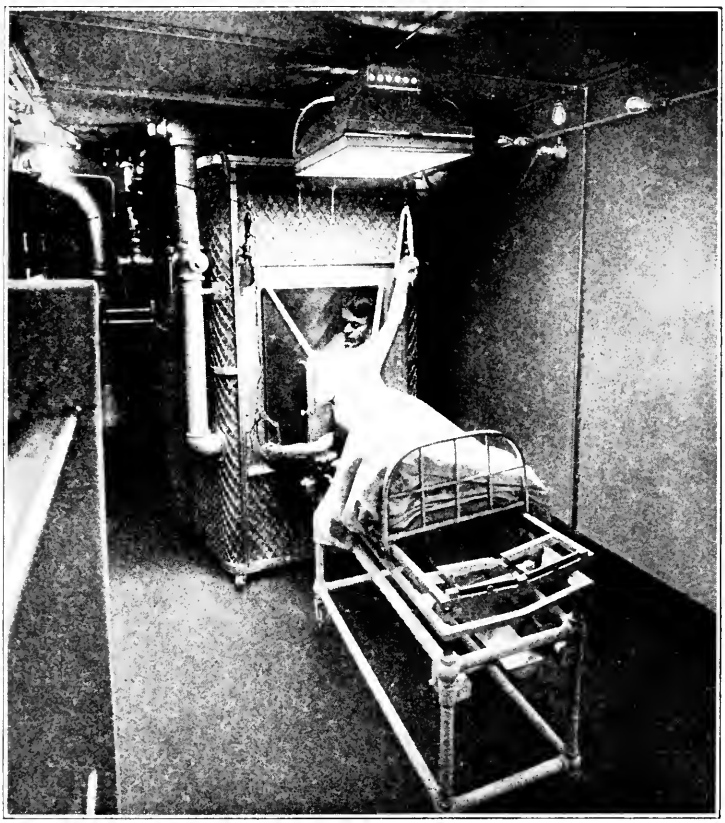


FIG. 59. Interior view of the negative chamber, at the pavilion for thoracic surgery, Lenox Hill Hospital, New York City. Patient placed on special operating table, lateral posture. The anesthetist and the patient's head are inside of the positive cabinet which stands within the chamber.

If the ordinary operating table is employed, a number of cushions or sand-bags must be arranged under the knee of the side pointing upward and under the pelvis in a manner to hold the patient in a pronounced Syms' posture. The free hand and arm should be covered with sterile towels, which are held by a bandage, and should be raised and abducted toward the opposite side, in order to get the scapula as much as possible forward.

It is a great convenience for operator and assistants to have a low table on hand and strong overhead light.

Position of Surgeon and his Assistants.—The surgeon ,I think, stands most conveniently on the right side of the operating table, facing the patient's front, while the first assistant is directly opposite. Some surgeons prefer the opposite arrangement, *i. e.*, to face the patient's back. If available, there should be an assistant to the left of operator and to the left of the first assistant.

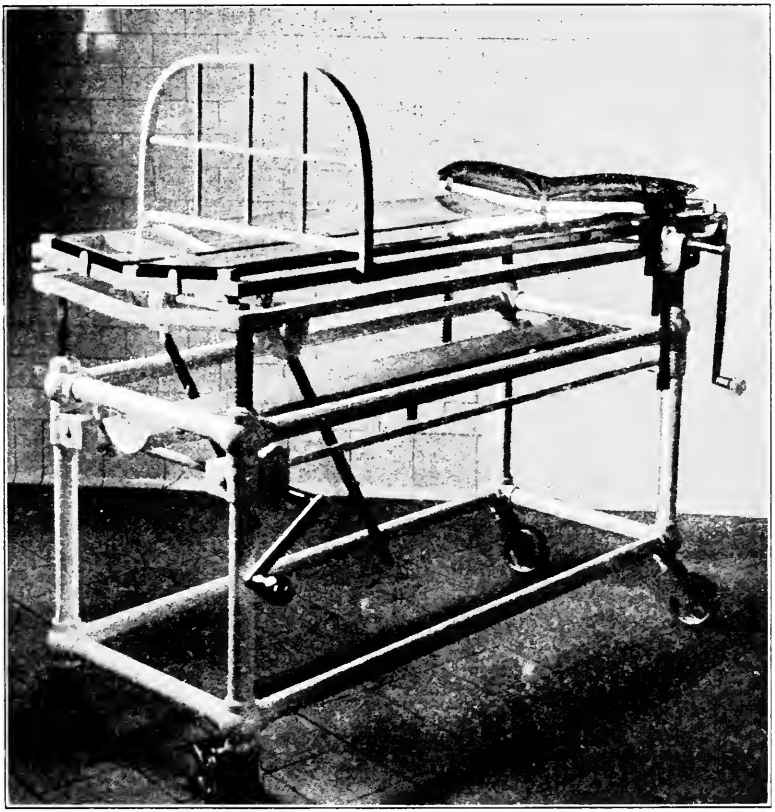


FIG. 60.—Author's operating table for thoracic operations.

Incision.—It is necessary to get the scapula out of the way: Originally this was done with the help of an additional operation on the soft tissues: Schede's incision, which lifts the scapula off the chest-wall, and one or two intercostal incisions, usually in the seventh or eighth interspace and, whenever necessary, also in the third intercostal space.

In 1913 F. Torek, of the Lenox Hill Hospital of New York, advised curving the posterior extremity of the skin incision in the seventh interspace upward and making it run over the angles of four to five ribs, between the inner border of the scapula and of the spinal column.

parallel with the spinous processes of the latter. After division of the muscles of the back, latissimus dorsi, part of major rhomboid and if required of the superior serratus posticus, the bundles of the erector trunci muscle are pushed inward and the ribs exposed and cut with bone scissors, either at their angles or between the angle and the spine (Fig. 61) one after the other, while the underlying soft parts, inclusive of costal pleura, are divided gradatim from rib to rib and

FIG. 61.—Torek's incision.

the intercostal arteries caught and ligated. The division of four ribs, seventh to fourth inclusive, usually suffices. If direct access to the vault of the pleural cavity must be had, the third rib, too, may be divided.[1] Now the rib-spreader is put in place, the anterior portion of the ribs, plus overlying scapula are pressed forward as a whole, yield-

[1] It stands to reason, that the same kind of division of the eighth and ninth rib can be added, should exceptionally more room be required toward the diaphragm.

ing through the elasticity of the rib cartilages, and splendid access is obtained.

In advanced cases of esophageal carcinoma it seems advisable to commence with the plain intercostal incision for exploration and not to add at once the division of the ribs upward.

If the rib-spreader sufficiently separates the intercostal incision, it may be feasible, before proceeding any further, to search for metastatic nodules in the lungs, pleura, etc. and thus determine the operability or inoperability of the tumor right there and then. Often, however, particularly in older patients, the access through the plain intercostal incision is unsatisfactory. It may be improved by dividing the intercostal muscles *beyond* the angle of the ribs, more toward the spine. But, at all events, the ribs must be spread with slow deliberation, not with a jerk, or the lower rib may break in this manœuver; and while no great harm would be done by the accident, it is better to avoid it.

Exposure of the Tumor.—After wide entrance has been gained, the next step is the palpation and exposure of the tumor. For this purpose the posterior mediastinum must be made accessible from the aortic arch down to the diaphragm. The posterior mediastinum is here only covered with a straight sweep of the costal pleura, from the inner surface of the ribs toward the lung. The organ which is oftenest in the way is the lung, owing to the manifold adhesions in this region, most likely due to more or less severe attacks of peri-esophagitis in the region of the tumor, which involved the costal pleura. These adhesions must be severed with great care with knife or scissors after the superficial incision has been made. A gauze swab on a handle, or the surgeon's gloved fingers, gently worked, will also be found most efficient for the separation. Firm bands require ligation and division. Here again careful attention is necessary, as the lung is very apt to be drawn out cone shape. In that event the band may contain lung tissue. The ligature must not involve the cone, but must be placed beyond its apex; otherwise the lung may be injured, and nothing is more irritating to the surgeon than to commence the intrathoracic work with a wound in the lung. If an injury does occur, it should be attended to at once, and not left to the end, when it may be forgotten. A wound in the lung is of little importance, if the surgeon expects to drain the pleural cavity at the end of the operation. They heal nicely under such conditions. But, if he intends to blow the lung up before finally closing the chest, in order to bring the pulmonal pleura in contact with the costal, the wound must have first been closed.

It is self-evident, that only bands and adhesions between pulmonary and costal pleura in the lateral portion of the chest, and over aorta and posterior mediastinum need separation. Adhesions at the apex of the lung and between its base and the diaphragm may be left alone.

The task of freeing the lung having been accomplished, the anesthetist is instructed to reduce the air-pressure somewhat, which causes

a corresponding collapse of the exposed lung. This step facilitates the surveying of the depth of the chest, as the inflated human lung is a very bulky organ and obstructs the view, but collapsing, it retracts upon the hilum and thus uncovers the field of operation. If left inflated, it would be necessary, in order to obtain the same free space, to exert a pull by hand or broad blunt retractor upon the lung tissue, which might damage it. In the free space obtained by the lung retraction good surgery can be done.

But while the lung is more or less collapsed both surgeon and anesthetist must be very much on the alert and constantly keep in mind the danger of a double pneumothorax. On severing firm peri-esophageal adhesions, the opposite pleural cavity may be invaded. A peculiar hissing noise produced by the entrance and exit of air into and out of the second pleural cavity through the narrow rent, announces this unintended communication, and the more air enters, the more also the second lung collapses. In that event, the air pressure must be promptly raised Both lungs must never be allowed to remain collapsed for any length of time. The heart does not tolerate a prolonged acute double pneumothorax. The blood-pressure drops rapidly. It can be brought back to normal by a series of rhythmic raisings and lowerings of the air pressure, under the influence of which the lung is inflated and deflated: artificial respiration. There is, in fact, no better and more promptly acting heart stimulant than repeated *pronounced* changes in the air pressure from the apparatus.

Thoracic operations require an especially trained and careful anesthetist. If anywhere in surgery, then here, teamwork is essential to success. The surgeon must not be required to pay attention to the needs of the anesthesia. He may give certain orders regarding pressure, as just stated, but then his mind must be relieved from further responsibility in this direction. His attention is needed elsewhere.

If, in severing the pulmonary adhesions, the posterior mediastinum has been inadvertently entered, then this hole or rent in the mediastinal (costal) pleura is used for advance toward the esophagus. Otherwise a free-hand incision through the mediastinal pleura is made with the knife, parallel with and about one inch away from the right border of the descending aorta. By spreading the branches of a pair of blunt scissors, or by introducing and separating two fingers, the mediastinal opening is enlarged and the tumor approached. One is thus able to feel plainly the extent of the cancer and the condition of the peri-esophageal tissue. If the tumor appears massive and infiltrating and is not easily surrounded by the gently advancing forefinger; if it extends up to the aortic arch; further, if the history of the case shows that a *stricture* had existed for five to six months and that sounding of the esophagus had been done repeatedly, it is wise not to continue the intended radical work. If insisted in, the drama is quite apt to be transformed into a tragedy, because, as emphasized before, the necessity of the *blunt* severing of firm and far-reaching adhesions behind the aortic arch, *at the very root of life*, almost without exception

means the death of the patient at the end of or soon after the completion of the difficult work.

On the other hand, if the tumor is localized, so that 1 to 2 inches of non-infiltrated esophageal wall can be palpated below the aortic arch, if the tube does not appear to be "cemented in" in the posterior mediastinum, then there is justification for deciding on resection. The extent of the tumor downward toward the cardia is of less moment, provided it stops short of the cardia. Involvement of the cardia necessitates a different operative procedure. (See below.)

The most favorable cases for radical operation, as stated above, are the localized, non-infiltrating tumors, bounded by a healthy piece of esophagus below the aortic arch and above the diaphragm.

Excision having been decided on, everybody and everything must be bent on deliberate advance. The healthy portion of the esophagus below the tumor is primarily approached. The left forefinger surrounds it gently, including both pneumogastries. While lifting it up, a long piece of tape is conducted around it by means of a slender, curved forceps or Dechamp's needle. By holding the two ends of the tape apart, the nervi vagi are made visible. They are carefully followed upward. If one of them can be separated from the tumor, a great deal has been won for the patient. If both can be saved, this is exceptionally fortunate. If both are surrounded by the growth, or intimately attached to it, it is better to cut them both primarily with scissors, in preference to subjecting them to much blunt handling. If only one is hopelessly involved, this one is divided. Immediately the proximal border of the tumor is next approached, in order to attend to the nervi vagi at this place. For it must be remembered that repeated tugging on, and irritating of, the branches of the anterior and posterior esophageal plexus adds continuously, at first perhaps unnoticed, to the slow development of shock, likely also to postoperative pneumonia. Therefore, when following the nerves upward, the surgeon should disregard the loosening of the tumor, and, leaving it untouched, should first attend to the nerves above it. It will not be difficult to find the nerves here, and either inject them directly with a 0.5 per cent. novocain-adrenalin solution, taking care not to make this nerve puncture too close to the aortic arch, or else infiltrate the perineural tissue with the solution. After a few minutes' wait for the solution to take effect, the same nerve that had to be divided below is now also cut above.[1] Then the other nerve, the one that can be saved, or in the "real lucky" cases both nerves, is followed downward and freed thoroughly. Now the tumor-bearing portion is shelled out, the surgeon always keeping faithfully in mind the topographic anatomy, as described above.

In cases in which the growth reaches up behind the aortic arch, or is situated at this very place, blunt loosening of the esophagus, without the guidance of the surgeon's eyes, is not permissible. Here the arch

[1] Further research is needed with reference to the necessity (or advisability) of cocainizing one or both pneumogastrics for the required work.

of the aorta and the first few inches of its descending portion must be mobilized (Ach, Rehn Jr., Torek). This is done without difficulty by division of the respective intercostal arteries, after previous double ligation. The aortic arch must be handled gently when lifting it aside.

When the tumor has been freed all around, a piece of tape or, if this be not on hand, a twisted piece of gauze, is conducted around the esophagus above and below the tumor.

It will be noted that, up to this time, the asepsis has remained unbroken. Local or general reasons making such a course advisable, the operation could, therefore, still be broken off, the operation thus remaining an exploratory thoracotomy.

Resection of the Tumor.—At this stage the intrathoracic work is interrupted for a few moments and the patient turned over more on his back in order to expose the esophagus above the left clavicle. It is annoying to cover and rearrange the operating field for this purpose. It is wiser—and I have done so in the last several years—to commence the operation with the cervical incision (external esophagotomy), surrounding the esophagus with a piece of tape which is dropped into the wound, while the latter is loosely tamponed and temporarily closed with a few stitches or clamps. No harm has been done, should the case prove inoperable in the course of the operation. A few stitches close the wound.

Instead of doing preliminary external esophagotomy the surgeon can also make his way toward the skin of the neck along the esophagus with his fingers from within, in the course of the operation, bluntly incise on to his spread fingers or upon a blunt instrument introduced from within, and then transpose the esophagus through the neck wound by pulling on the thread with which the proximal end of the tube was tied off.

This method, though, does not appear as safe as external esophagotomy. I have, on one occasion, seen an esophagus tear off on being pulled out through the neck wound, when thus handled from within.

If the surgeon preferred to do external esophagotomy in the course of the operation, he now returns to the thorax. The moist towels and sponges, temporarily placed, are removed and the esophagus lifted out of its bed by means of the two tapes. It is pulled upward on the lower tape and a purse-string suture of chromicized catgut is placed fully one and a half to two inches below the spot at which one expects to divide the esophagus. This thread must be long. Three loops are formed and the knot of each secured with a non-biting clamp, all three clamps being of the same type, while the two ends of the thread are clamped with a forceps of different type (Fig. 62). Thereupon the operation proceeds as follows:

1. Division of the esophagus below the tumor: A clamp is placed right below the tumor and firmly closed, and a silk ligature or one of thin tape, tied around the tube about five-eighths-inch farther down. Thorough tamponade with gauze all around; division of esophagus between these two marks, either with the active cautery or with the

knife. If the latter is used, the stumps can be sterilized immediately afterward with the active cautery, or must be disinfected with pure carbolic acid, followed by alcohol.

2. Burying of the lower stump: The surgeon takes hold of the clamps of the three loops with one hand and of the two clamped ends of the thread with the other. He pulls them well apart, thus unfolding the tube, and has the first assistant invert the stump. In this way the inversion becomes an easy procedure (Fig. 62). While the first

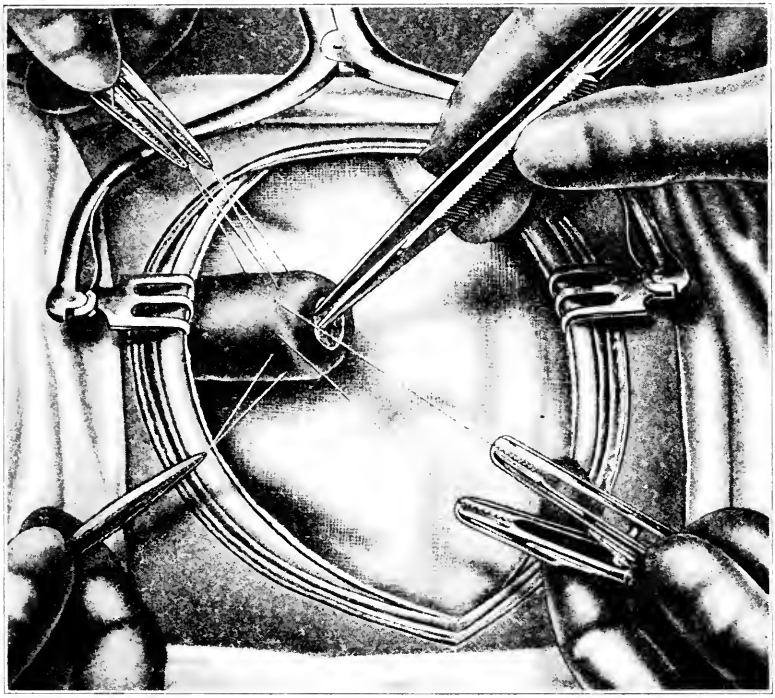


FIG. 62.—After protection of operating field, the esophagus has been divided with cautery or scissors. If with the latter, the stump is touched up with carbolic acid and alcohol. While the operator holds the three loops tight, the assistant invaginates the stump with his right hand; at the same time the operator pulls on the two ends of the thread until the clamps fixating the loops reach the wall of the esophagus, when they are removed.

assistant, with a long anatomical forceps, steadily holds the stump inverted, the operator pulls on the two ends of the purse-string suture, and the second assistant removes one clamp after the other from the loops. Thus the purse-string suture is tightened and inversion made doubly sure, which, without properly secured loops of the purse-string suture, would by no means always be an easy matter in the depth of the thorax. The long purse-string thread, tied and not cut short, affords a splendid hold on the stump. With it, the stump is pulled up, and three additional Cushing sutures with fine silk or linen thread are

placed and closed at either end first, then in the middle, after the purse-string suture has been cut short. Now the stump is allowed to drop back and disappears in the depth.

3. Extraction and Transposition of the proximal stump: The proximal stump must now be closed and removed from the mediastinum. There are two methods:

(*a*) *To Extract Stump and Tumor Together.*—Instead of clamping the esophagus below the tumor, a ligature might have been placed there. But, be it borne in mind, that nowhere does a mass ligature, no matter of what material, slip off more readily, than from the short stump of the esophagus. The safest closure is that by Ach's method: transfixion with needle and thread and ligation to either side, same as we are wont to proceed in closing the neck of the hernial sac. Of course, this introduces an element of sepsis. However, the possibility of infection is but slight, if the stump is at once iodined and extraction of it done without delay. This extraction is sometimes accomplished easily, with a jerk of the left forefinger which surrounds the esophagus above the clavicle within the esophagotomy wound. I have succeeded a number of times in extracting it in this way, without a hitch. In other cases the many adhesions of the esophagus to the aorta by short arteries, and to the pneumogastric nerves, would not yield all at the same time. Then the esophagus had to be loosened gradually and placed in front of the aortic arch. Only then the stump would yield to the traction at the neck.

The second method is apparently more recommendable, viz.:

(*b*) *To resect the tumor first and then extract the stump*, delivering it through the neck wound.

In both cases the extracted stump is placed antethoracically under the skin, being pulled through a bluntly-made tunnel. It is left closed and its tip secured within the transverse incision of the skin of the chest by a few stitches.

Closure of Thoracic Wound.—(*a*) *Without Drainage.*—The whole operative field, particularly the posterior mediastinum is wiped clean and revised for hemorrhage. Where found, ligatures are placed. Then 3 to 4 pericostal (Fig. 63*A*), or percostal (Fig. 63*B*) silk or strong chromicized catgut sutures bring the two ribs in apposition. The third method is to perforate the lower rib only and make the thread surround the rib above (Fig. 63*C*).

For the percostal suture, or its modification, Friedrich's rib puncher and thread guide (Fig. 64*a* and *b*) are preferable to a drill. I prefer silk sutures first, and next to each, a stout chromicized catgut suture. The silk sutures are first pulled taut by operator and assistant simultaneously, and tied. Then the catgut sutures are united, thus having to bear much less strain, and the silk ones are removed. In cases of wound disturbance I have seen the silk threads act as foreign bodies which had to be removed.

The posterior rib divisions are not sutured. Continuous layer suture of catgut of muscles and skin with catgut; finally, the lung is thor-

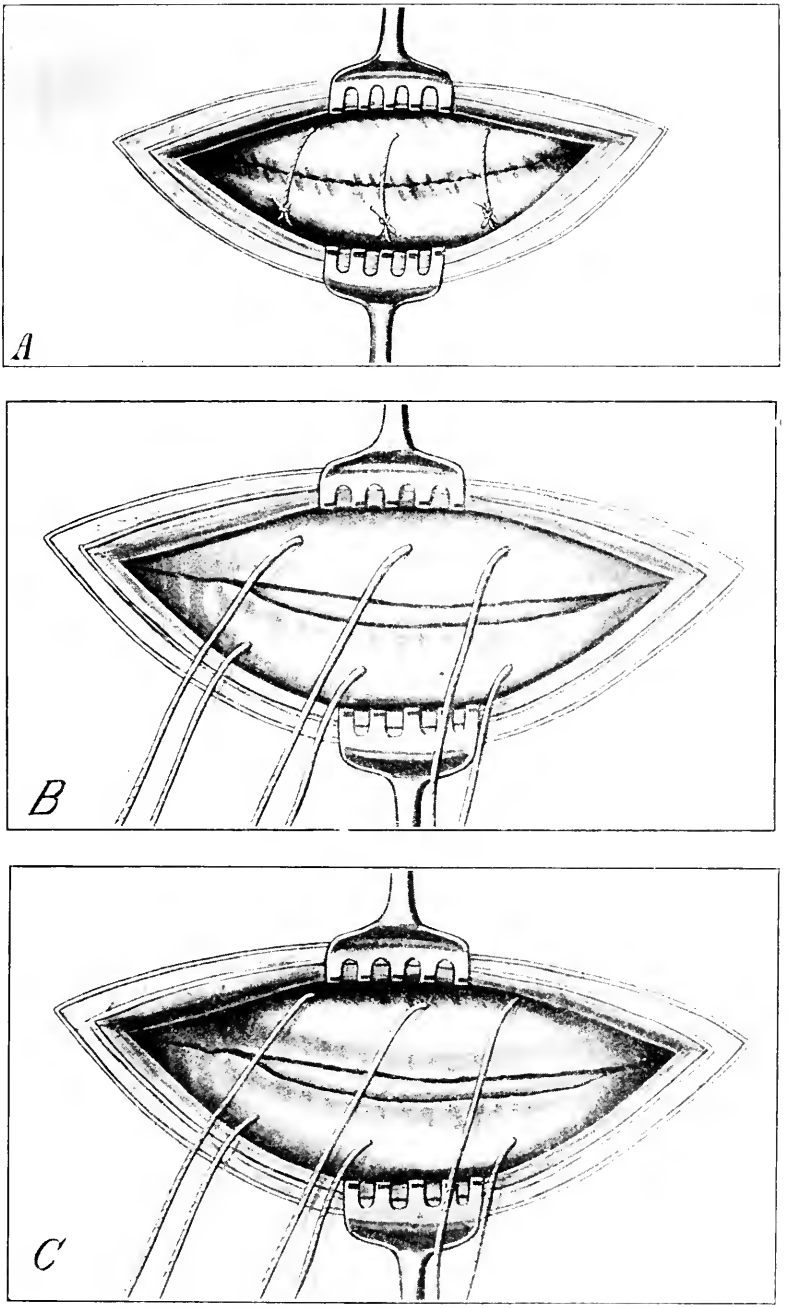


FIG. 63.—A, pericostal suture; B, percostal suture, to avoid possible neuralgias of the intercostal nerve; C, modified percostal suture, only the lower rib is perforated, the upper one is surrounded by the thread. The pericostal suture seems to deserve the preference, as it is the simplest and most easily placed.

oughly distended in order to expel the air from the pleural cavity and bring the visceral and the parietal pleura to contact. It does not matter much if the apposition is not perfect and some air remains within the pleural cavity. It will soon be absorbed. Still it is best to try and press all the air out of the pleural cavity. The suture line is wiped with iodine and a gauze dressing applied, held by broad strips of adhesive plaster which fixate the arm to the chest, but must not compress the transposed esophageal stump.

(*b*) *With Drainage.*—The writer firmly believes in the necessity of following the same general surgical principles in conducting thoracic surgery as elsewhere. The pleura has a great tendency to throw out

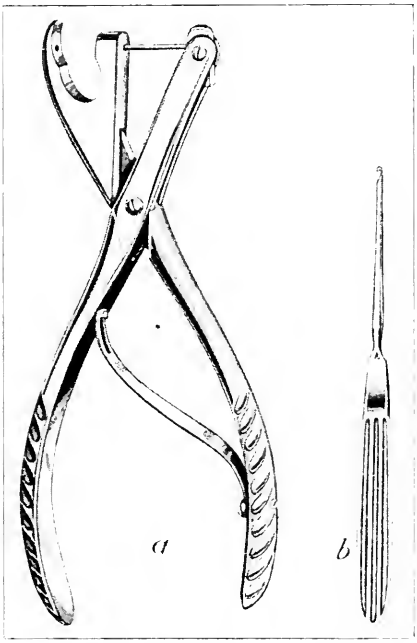


FIG. 64.—Friedrich's rip-puncher, *a*, and thread guide, *b*.

a serosanguinolent massive effusion on the slightest septic or mechanical provocation. Both are invited in esophageal surgery. This effusion with its sequelæ has everywhere been the cause of death or certainly a contributing factor to the fatal issue in a large number of patients subjected to esophageal resection. Therefore, I hold that all these cases should be drained.

The danger incident to drainage is postoperative acute pneumothorax, which, of course, must be guarded against. The problem can be solved in many ways. So far the following three methods have been employed:

1. Closing the main wound as above described and draining the cavity with a cigarette drain and split rubber tubes through a wide

intercostal incision in one of the lower intercostal spaces, covering the skin plus the securing safety pins at the outer end of the tubes: (1) with a split piece of gauze slipped under them; (2) with a large

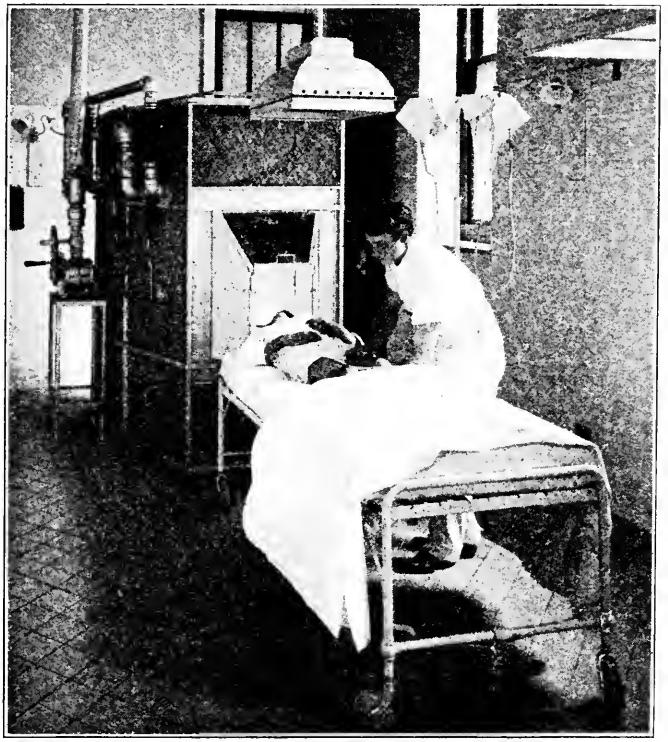


FIG. 65.—Illustrates the after-treatment of patients with free drainage after intrathoracic operations, as first practised at the Lenox Hill Hospital. The patient's head is inside the positive pressure cabinet; a nurse is with him ready to administer liquids or, in summer time, to fan him with fresh air provided by the apparatus itself through a large tube. The patient's body rests comfortably outside, on a bed without headpiece. An attendant is watching the proper administration of a rectoclysis.

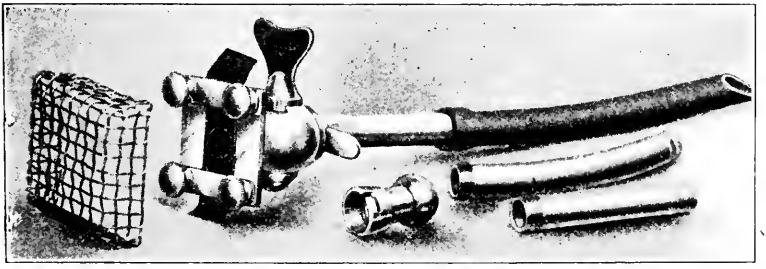


FIG. 66.—Tiegel's thoracic flexible metal drain. The tube that passes through the thoracic wall can be properly bent to correspond with the contours of the posterior thoracic wall. It is advisable to slip a rubber drainage tube over the internal extremity of the tube. Note the rubber membrane that covers the external opening and allows the exit of fluids and air, but prevents the entrance of air.

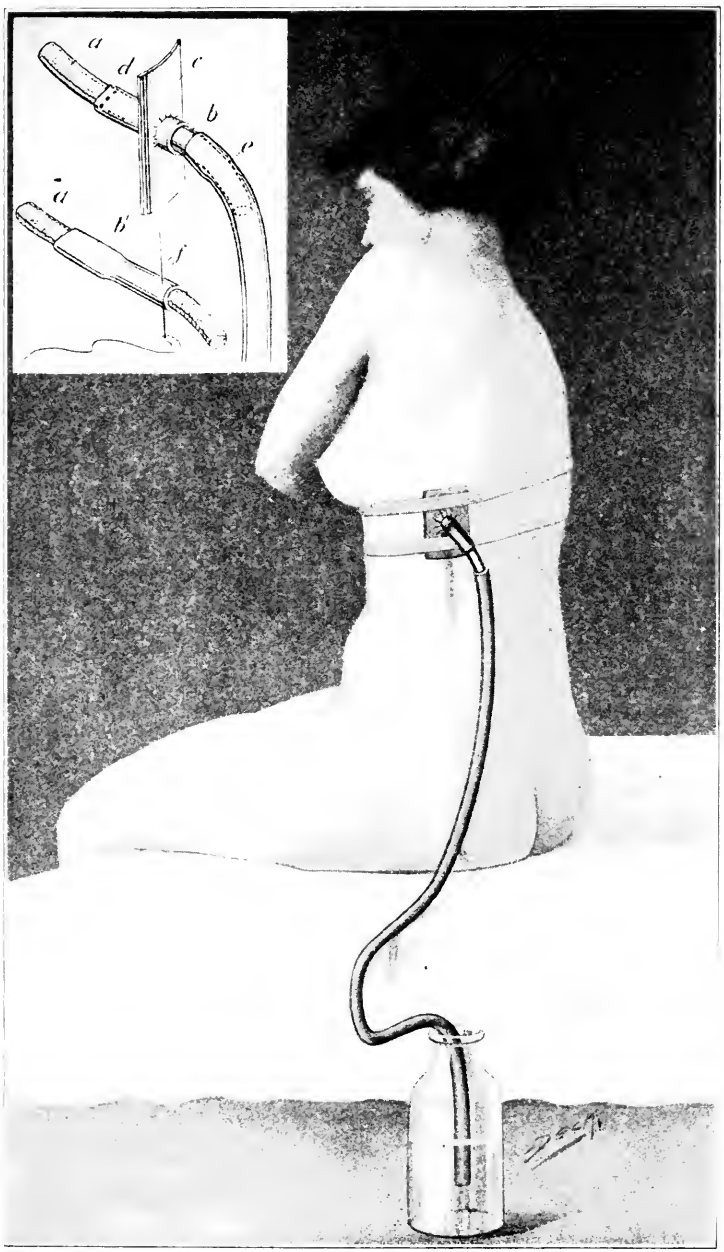


FIG. 67.—Kenyon's method of draining the pleural cavity and avoidance of post-operative pneumothorax, modified and adapted to intrathoracic operations other than drainage of empyema. A metal tube (*b*) round outside and flattened on its way through the intercostal space (*b'*) is covered with rubber tubing. (See inset.) The inner end of the rubber tube has a number of holes for additional drainage (*d*) and projects from the metal tube for about one-half inch. The outer end dips into a bottle which is partially filled with fluid and placed under the bed. An interposed short glass tube permits of observation

piece of rubber dam, the borders of which are attached to the chest wall by zinc ointment previously spread on the skin around the wound. (Such covering with a piece of rubber dam is essential.) The patient is kept under differential pressure (Fig. 65). The method has proved its usefulness, but it is cumbersome.[1]

2. *Tiegel's Drain*,[2] made of metal, covered outside with a rubber membrane, permitting drainage of fluid, but no entrance of air (no personal experience) (Fig. 66).

3. *Kenyon's Method*.[3]—With the courteous coöperation of Dr. James H. Kenyon, I first tried his method of thoracic drainage in a case of resection of the esophagus for carcinoma, in the fall of 1915, in a somewhat modified form (Fig. 67, inset) as discussed between us prior to the operation. Although the patient did not live long enough after the operation to give us the chance of a thorough trial, the method decidedly impressed me favorably, because it combines air-tight closure of the thoracic cavity—Sauerbruch's condition *sine qua non*, for operations within the thorax—with thorough drainage of the pleural cavity as well as (if desired) of the esophageal bed in the posterior mediastinum. It allows of the introduction of a special capillary cigarette-drain through the metal tube, which drains the pleural cavity without disturbance of the air-tight occlusion of the chest. The cigarette-drain is securely retained by a stitch which passes through its middle and two holes drilled through the end of the metal tube (Fig. 67). The appeal of the method is in its coincidence with tried and accepted ideas of normal cavity drainage.

The described arrangement was used in the first case only. Soon the metal tube was replaced by a rubber drain of about the size of a man's middle finger, with one or two end holes after thoracic operations other than resection of the esophagus. The tube ismade to pass a thin, round

[1] Meyer, Willy: Ann. Surg., 1912, xvi.
[2] Centralbl. f. Chir., 1911, No. 10.
[3] Johnson's Operative Therapeusis, i, 241.

CONTINUATION OF LEGEND OF FIG. 67.

of the character of the fluid that drains from the pleural cavity. A square rubber cuff (*c*) cemented to the rubber cover of the metal tube rests on a small split gauze pad which covers the wound. The rubber cuff is again covered with a piece of perforated cork; this is secured to the chest-wall by broad strips of zinc adhesive plaster. For cases of resection of the esophagus a cigarette drain (*a c* and a^1) more than two feet long, is placed into the bed of the extracted esophagus in the posterior mediastinum; it passes through the metal tube without entirely filling its lumen and is held securely in place by a silk or linen thread stitch which passes through it and also through the two opposite holes at the outer extremity of the metal tube (*f*). With the patient placed under temporary differential pressure, the cigarette drain can be gradually shortened after forty-eight to seventy-two hours and finally withdrawn altogether. After a number of days, when the danger of an acute pneumothorax has passed, the drainage apparatus may be replaced by an ordinary tube, the latter to remain in place for a short time longer.

This drainage of the bed of the esophagus by means of a long cigarette drain is of importance in cases of resection of the esophagus, because the distended lung with its covering visceral pleura usually becomes firmly adherent to the costal pleura within a very short time (twelve to twenty hours). It thus shuts off the posterior mediastinum in case direct drainage of the same has been omitted.

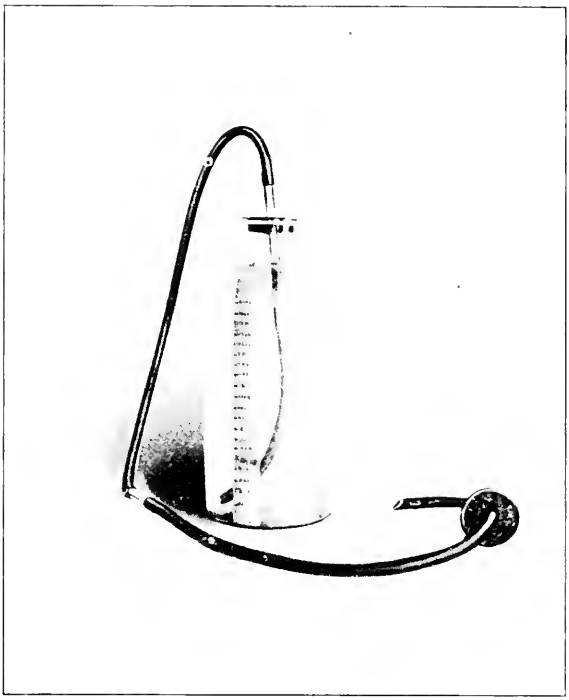


FIG. 68.—Syphon bottle with drainage tube; the latter passes through a hole in the center of a round piece of thin cork, the hole having a smaller diameter than the outside diameter of the tube.

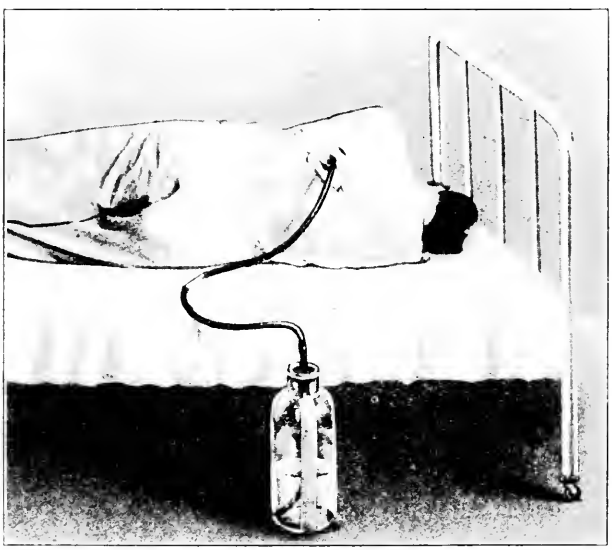


FIG. 69.—Air-tight thoracic drainage, as used by the author at present.

piece of cork with a central hole which is somewhat smaller in size than the circumference of the tube (Figs. 68 and 69). The arrangement outside has remained the same.

The whole apparatus is sterilized by boiling. The tube is introduced one or two intercostal spaces below the thoracic incision, usually in the posterior axillary line. Skin and fascia only are incised, the intercostal muscles with endothoracic fascia and costal pleura bluntly perforated. Muscles, fascia and skin are then stitched in layers tightly around the tube.

The method corresponds with Bulau's thoracic drainage, devised more than twenty-five years ago and used by him in the treatment of empyema.

In view of the results obtained I have adopted it as the standard method for thoracic drainage.

The fact that the only so far recorded case of recovery after resection of the thoracic portion of the esophagus, that of Dr. F. Torek,[1] of the Lenox Hill Hospital of New York City, healed without drainage[2] is no valid argument for making non-drainage the method of choice in this operation. A great number of cases stand out against it, in which autopsy showed that death occurred as a result of a septic serosanguinolent effusion that had accumulated in the pleural cavity and could not drain off. It certainly seems an unavoidable conclusion to be drawn from the many fatal issues after this operation, that omission of drainage has been one of the many contributory factors in the outcome. In other words, drainage after resection of the esophagus, in fact, after any intrathoracic operation that required opening the lumen of the esophagus, is essential and imperative. Not draining, to my mind, means taking chances, working without a method of after-treatment which greatly helps to ensure the success of the complicated and serious operation.

Personally I am employing this "air-tight" thoracic drainage (Figs. 68 and 69), after every thoracic operation.[3]

A valuable contribution to this question has recently been furnished by Adr. J. Bengoela of Buenos Ayres, Argentine.[4] It refers to a woman, aged thirty-seven years, weighing seventy-seven pounds, in whom intrathoracic resection of the esophagus for carcinoma in the lower portion and esophagogastrostomy with the help of a wooden bobbin was done, the patient living thirty-seven days after operation. There is no question in my mind that the air-tight thoracic drainage, commenced at the close of the operation, had a great deal to do with the immediate favorable result of the serious operation in this greatly reduced patient. Unfortunately, symptoms of suture insufficiency set in on the fifteenth day, and the patient died of septic empyema five and a half weeks after the operation, her regained ability to swallow, however, not having become impaired up to the last.

[1] Jour. Am. Med. Assn., 1913, No. 20, lx.

[2] This patient is still alive six and one-half years after the operation and in splendid condition.

[3] Annals of Surgery August, 1918, lxviii 157.

[4] Surg., Gynec. and Obstet., October, 1919, p. 413.

3. *Resection of the Cardia for Carcinoma.*—As has been stated above, malignant tumors developing at the hiatus esophageus and those stenosing the cardia, must clinically be grouped under one heading. To be added to this group, as requiring the same type of operation, are,

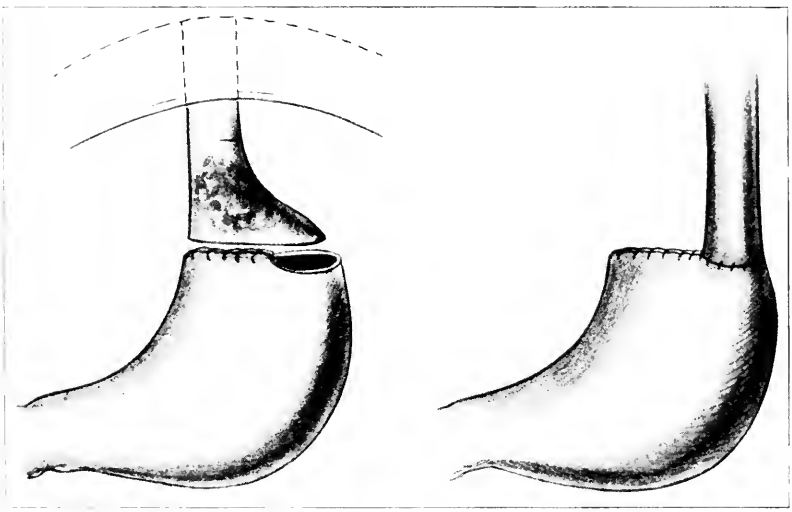


FIG. 70. First successful case of resection of the cardia for carcinoma. (Völcker.) Removal of tumor entirely from below through the abdomen. Immediate end-to-end union by Billroth's method No. 1. Tamponade; temporary leakage; recovery.

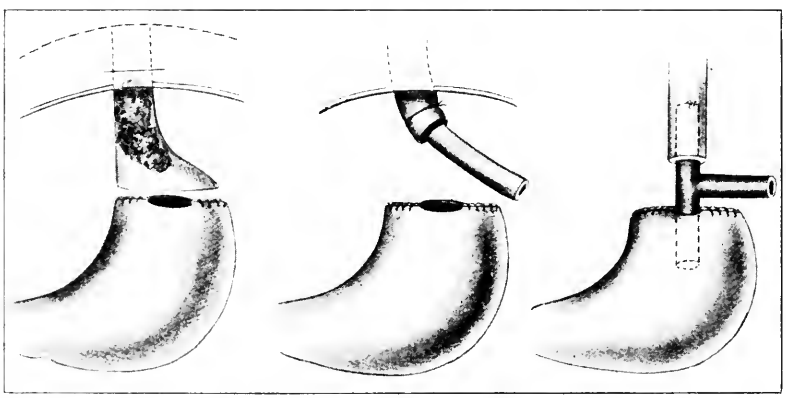


FIG. 71.—Second successful case of resection of the cardia for carcinoma. (Kuemmel, diagram drawn by writer.) In this case, too, the operation could be done entirely within the abdomen; pleural sacs were not interfered with, as cardia, after being loosened, could be pulled down for a distance of 10 to 12 cm. Immediate union impossible, as distance between resected parts was too long; tube tied in esophagus; gastrostomy; subdiaphragmatic tamponade; later T-tube; gradual closure.

further, carcinomas developing in the cardiac portion of the stomach. As mentioned, the two groups total up jointly to about 50 per cent. of the malignant growths of the esophagus. When we remember that carcinoma of the esophagus takes the fifth place as regards frequency of all carcinomas, the importance of this chapter becomes apparent.

So far, the majority of surgeons have thought best to pronounce as inoperable patients afflicted with cardiac carcinoma, simply on the ground of location. However, since we have now at our dis-

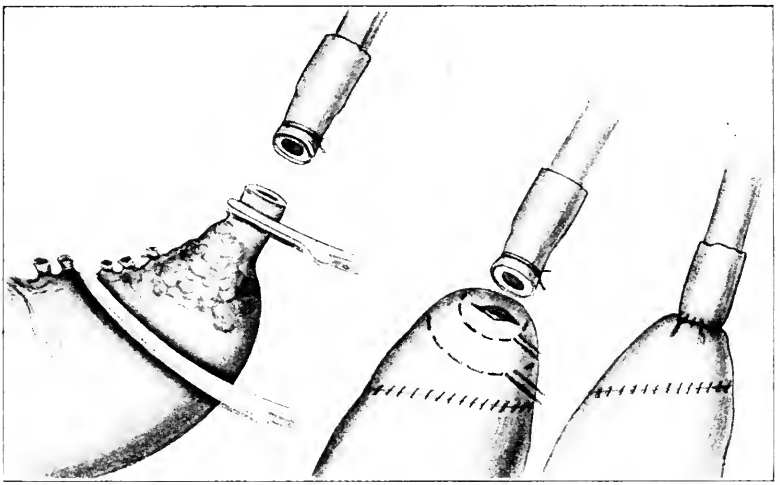


FIG. 72.—Third successful case of resection of the cardia for carcinoma; operative recovery. (Sauerbruch.) Transpleural operation under differential pressure; growth loosened from above; excision of tumor; closure of stomach; latter pulled up above diaphragm into thoracic cavity and anastomosis carried out with Tiegel's button. Operative recovery; pneumonia on sixteenth day; exitus.

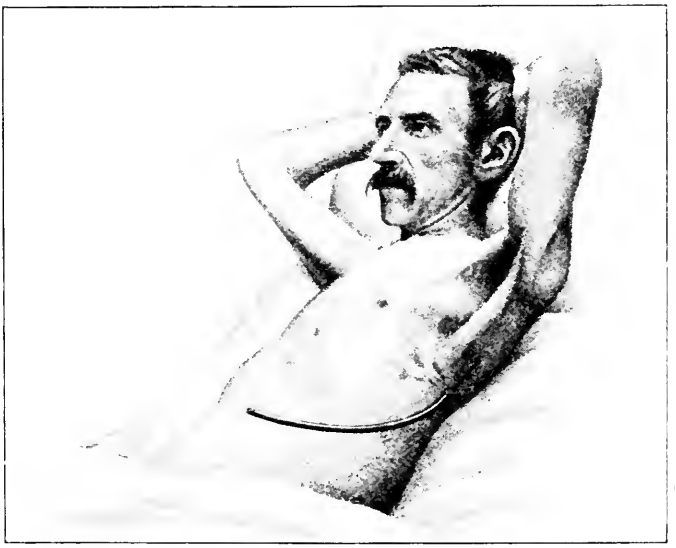


FIG. 73.—Fourth successful case of resection of the cardia for carcinoma. (Zaaijer.) After gastrostomy and resection of lower ribs in first and second stage, combined thoracotomy and abdominal section; excision of tumor; proximal stump left *in situ*, its lower end brought out in axillary line; patient well able to swallow after introduction of rubber tube. (The rubber tube is shown in the illustration.)

posal not only the means of overcoming the principal immediate danger of the operation, "the probable wounding of both pleural

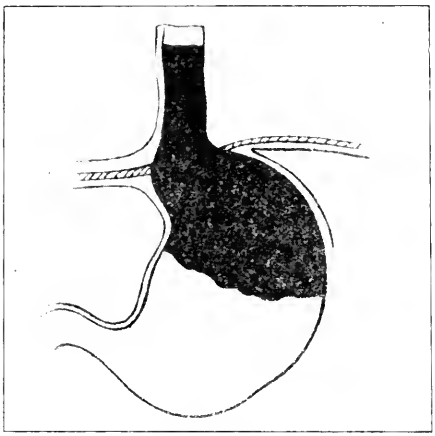


FIG. 74. Fifth case of resection of the cardia for carcinoma; operative recovery. (Ach. Munich, 1912.) The blackened part in diagram presents extent of tumor. Excision done from abdomen; extraction of proximal stump of divided esophagus by special method; gastrostomy added. Eleven days later beginning insufficiency of gastric fistula, to which patient succumbed on seventeenth day after operation.

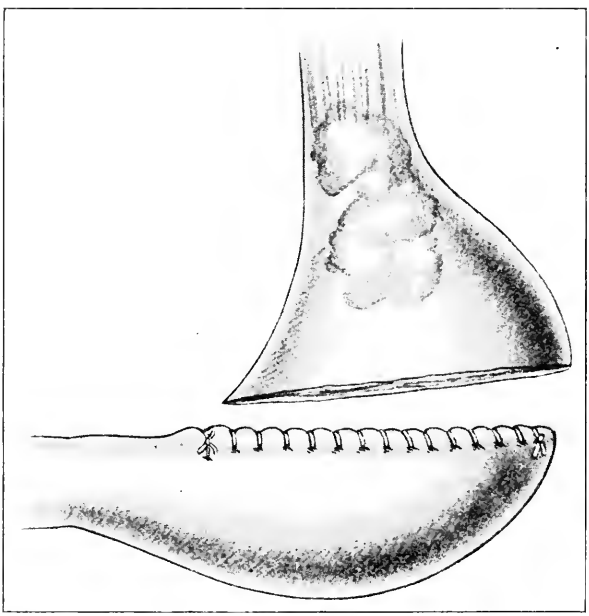


FIG. 75.—Pyloric portion of stomach, sutured after horizontal division into a sausage-shaped tube for antethoracic transposition in lower esophagoplasty. (Ach.)

cavities," but also efficient methods of operation and after-treatment, it seems to become our duty to give also this class of patients the chances of help which modern surgery holds out.

A perusal of the literature up to 1914 shows five operative recoveries reported since 1908, by German and Dutch surgeons: Völeker,[1] Kümmel,[2] Sauerbruch,[3] Zaaijer[4] and Aeh.[5] In each instance the task was solved in a different way (Figs. 70 to 75). However, on the basis of the experience had, it now seems possible to establish a method of procedure which is worthy of adoption as a routine measure. Yet,

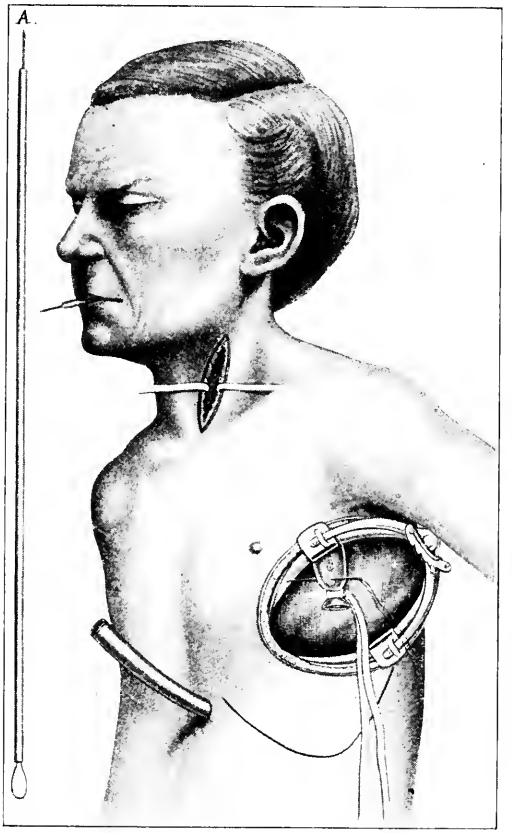


FIG. 76.—Thoracotomy added to laparotomy; rib spreader in place; proximal stump ligated with tape; needle with linen thread pierces the loop of the wire (Aeh) introduced by the narcotizer down to the point of ligation of the esophagus. Abdominal incision outlined.

as was to be expected, quite a number of important questions still await definite solution, and not ere then will there be justification for considering the operation firmly rooted.

[1] Verhandl. d. deutsch. Gesellsch. f. Chir., 1908, i, 126.
[2] Ibid., 1910, i, 96.
[3] Technik d. Thorax Chir., 1911, p. 87.
[4] Beitr. z. klin. Chir., 1913, lxxxiii, Heft 2.
[5] Beitr. z. Oesophagus Chir., Muenchen, 1913.

Foremost among them is this question: Can the hemorrhage from the short aortic branches of the esophageal arterial system have serious consequences, when, after resection of the cardiac tumor, the arteries are torn and left unattended in the extraction of the proximal healthy portion of the esophagus from the posterior mediastinum for antethoracic transposition? or, should these branches first be ligated? If it is found from clinical observation that such hemorrhage need not be feared, then resection of the cardia may often be done in two stages, if not in one.

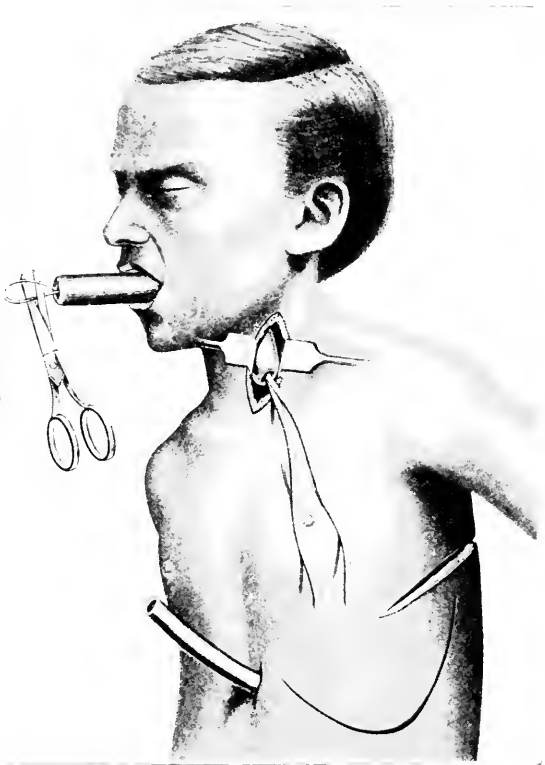


FIG. 77. Esophagus everted, extracted from the mouth of the patient by the narcotizer, until the tape, pulled up in the posterior mediastinum appears at level of the neck wound which is held apart by blunt retractors. The long ends of the piece of ligating tape are lifted out of the neck wound and placed on the chest. The thread in front of the mouth is divided with scissors by the narcotizer. Abdominal and thoracic wounds outlined. (See author: Resection of the Cardia for Carcinoma, Annals of Surgery, 1915, lxii, p. 693.

If, on the other hand, this hemorrhage is likely to cause trouble, then resection of the cardia will have to be done in three stages, the removal of the malignant tumor to be the last step.[1]

[1] Meyer, Willy: Centralbl. f. Chir., 1914, No. 32; 1915, No. 1; Annals of Surg., December, 1915.

We shall first consider—

The Three-stage Operation.—First Stage.—Gastrostomy, plus thorough direct palpation at and around the cardia, in order to determine the operability of the case. About two to three weeks later:

Second Stage.—Thoracotomy; division of the esophagus at a spot sufficiently distant from the upper end of the tumor (Fig. 76) to permit of safe inversion of the lower esophageal stump. Before inversion the stump is closed by a purse-string suture; loosening of

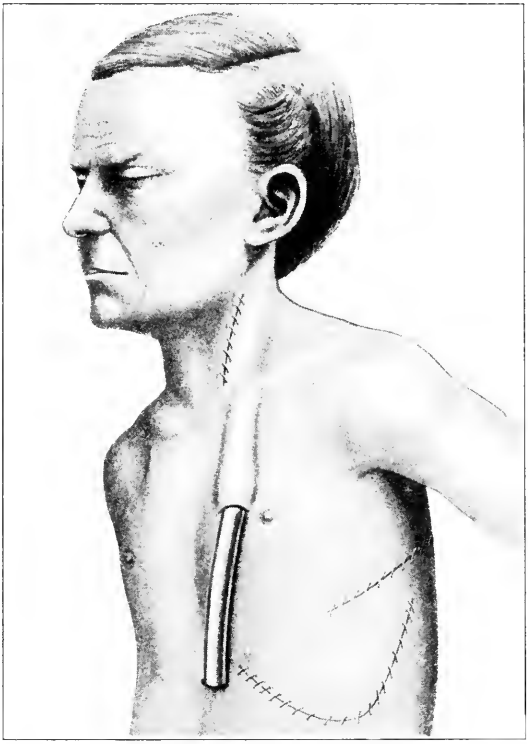


FIG. 78.—Proximal stump placed under the skin tunnel of the chest; lower end opened, stitched in place; rubber tube shown, as it would connect the lumen of the esophageal stump with the gastric fistula. (Gluck-Perthes method.)

the tumor. If the latter is small and circumscribed, an attempt may be made to invert it into the stomach together with the distal stump (Sauerbruch). Antethoracic, subcutaneous transposition of the proximal stump. The latter step renders the patient again capable of swallowing (Figs. 77 and 78).

Third Stage.—Oblique abdominal section, exposing the vault of the diaphragm (Fig. 79); gastric fistula preserved; osteoplastic resection of costal arch, if access be difficult; tumor and inverted lower esophageal stump loosened from below and slowly pulled into the

abdominal cavity; transverse resection of stomach within its healthy portion; suture of stomach wound; closure of abdominal incision.

In the *one-stage* as well as in the *two-stage* operation thoracotomy is avoided. Both operations are premised on the possibility of extracting the esophagus from the posterior mediastinum and inverting it upon itself. This can be accomplished with the help of Ach's wire extractor (Fig. 80 *A*, *B* and *C*) or by means of the esophageal extractor devised by the author, which latter renders the procedure more aseptic (Figs. 80 *D* and *E* and 81), or, in an emergency, by using the ordinary olive-pointed bougie.

Fig. 79.—Oblique abdominal incision in presence of gastric fistula. The artist has left the tube in place for demonstration. For the operation the tube had, of course, been removed and the fistula plugged with iodoform gauze and covered with sterilized adhesive plaster, which in addition had been painted with tincture of iodine.

The *two-stage* procedure is as follows:

First Stage.—Same as described in the foregoing three-stage operation.

Second Stage.—Oblique abdominal incision; manual loosening of tumor within the hiatus esophageus and the posterior mediastinum; clamp placed at the extreme upper pole of the growth (Fig. 82); securing of the lower end of the extractor within the healthy portion

of the esophagus above the clamp; division of the esophagus (Fig. 82) and immediate extraction of the proximal stump (Fig. 77); antethoracic subcutaneous transposition of the same (Fig. 78); isolation of the tumor by ligating its main feeding gastric arteries (Fig. 6, p. 24) resection of the stomach at a sufficient distance from the lower end of the tumor, arranging, if possible, to preserve a pyloric pouch of some size for later feeding through the gastric fistula (Fig. 82).

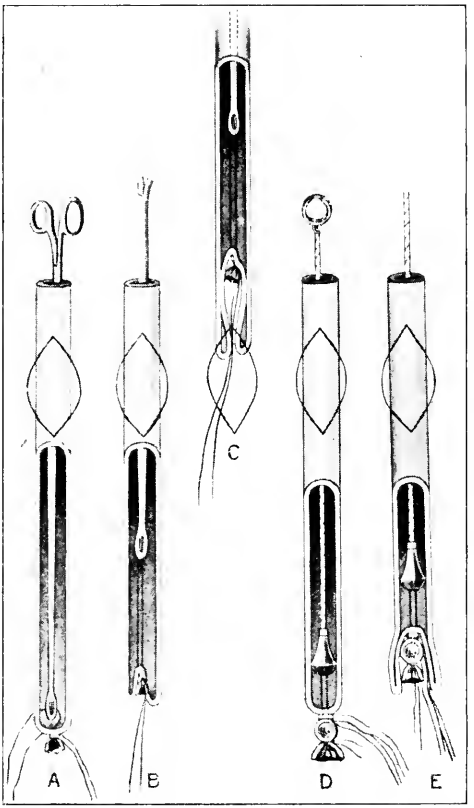


FIG. 80.—Diagrammatic; showing esophagus stump in course of extraction: *A*, *B* and *C* being done with Ach's wire extractor, *D* and *E* demonstrating the procedure with the author's extractor. The oval represents the neck wound which exposes the esophagus.

The One-stage Procedure.—The presence of the gastric fistula—the functioning of which must not be disturbed, or, if it had to be disturbed in the course of the operation, must be reëstablished at the completion of the same—is one of many features which make a three-stage operation little desirable. Attempts have therefore been made to get around this difficulty by doing the entire work in one stage, with gastrostomy as the last act (Ach). The usually required cutting of both pneumogastric nerves is apt to interfere with the watertight

condition of a gastric fistula, established according to any one of the older methods. Ach has, therefore, in two instances, resected the

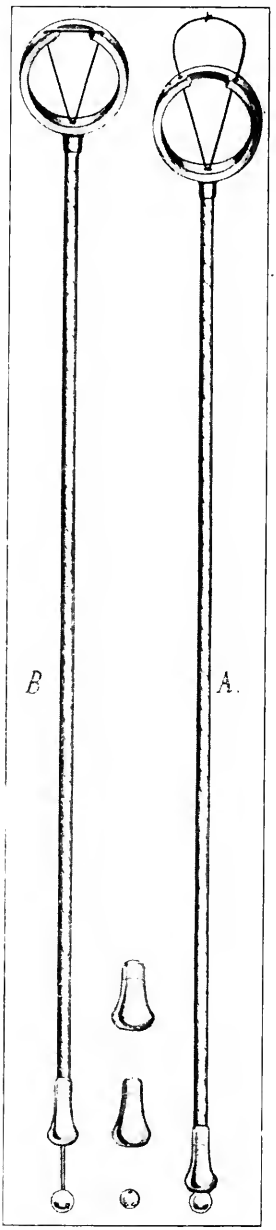


FIG. 81.—Author's esophageal extractor. It requires no piercing of the esophagus, thus rendering the extraction an absolutely aseptic procedure. *A*, ready for introduction, the perforated bullet is drawn up toward the sound's mushroom tip, which has a rounded border. *B*, the bullet milked down close to the ligated stump of the proximal end. Above it a tight ligature is then placed (see Figs. 80*D* and 80*E*).

stomach very obliquely and has closed the remaining pyloric portion by sutures in such a way that it formed a sort of sausage-shaped body which was then placed subcutaneously upward. This body takes the place of the gastrostomy canal. It cannot leak into the abdominal cavity and consequently, cannot become the cause of the patient's death (Fig. 75).

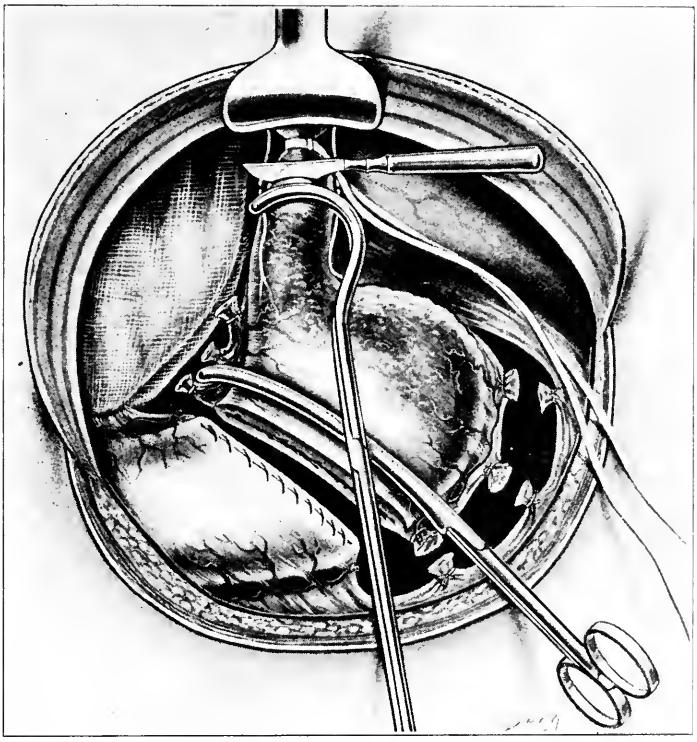


FIG. 82.—Liver covered with gauze sponge; tumor loosened in foramen esophageum, its upper end clamped with curved forceps; the proximal portion of the esophagus, about one inch above, tied off with a piece of narrow tape, the ends of which are left long. Nervi vagi divided; knife ready to cut through the esophagus. A blunt hook placed in the posterior mediastinum facilitates access.

Palliative Operation for Cancerous Stenosis of the Esophagus.—Whoever has attended patients afflicted with an impermeable stenosis of the esophagus, will have found that their inability to swallow is the greatest hardship of which they complain. It is this function above everything that they long to have restored. If then, on thoracotomy, the disease is found inoperable, why not proceed to restore to these patients the ability to swallow? The technic of the operation would be in line with that of Madelung's operation in cases of inoperable rectal carcinoma. It would consist in the performance of the second stage of the above-described three-stage method of resection of the cardia, viz., division of the esophagus proximally to the tumor, inversion of the

distal end and transposition of the oral stump under the skin of the neck and chest, the lumen of the esophagus then to be united with the gastrostomy opening by means of a rubber tube (Gluck,[1] Perthes[2]). Even in cases of apparently complete obstruction of the esophagus by the tumor, there is, likely, still sufficient drainage through a narrow and tortuous channel into the stomach, to render this operation practicable.

This palliative operation will in thoracic surgery take the place that gastro-enterostomy has in abdominal surgery in cases of inoperable carcinoma of the pylorus. Both are, to my mind, equally indicated to alleviate the patient's misery. His relatives are informed of the true state of affairs, but the patient—for some time at least—will consider himself cured, surely a justifiable deception.

FIG. 83.—Case of superior esophagoplasty for inoperable cancer of the cardia, showing the incision and point of air-tight thoracic drainage.

I have so far done this operation three times. In the first case, the malignant, inoperable tumor reached up behind the aortic arch. It was technically difficult to close the distal end securely for lack of material, and inversion of the stump was irksome. The proximal stump was barely long enough to be stitched to the skin, having been slipped underneath a narrow skin bridge. This patient lived only seven hours after the operation.[3] He was operated upon before the time that I adopted air-tight thoracic drainage in every case of thoracic operation.

[1] Berl. klin. Wchnschr., 1898.
[2] Verhandl. d. deutsch. Gesellsch. f. Chir. 34th Kongress, 1911.
[3] Surg., Gynec. and Obstet., 1915, pp. 162–170.

In future I shall do this operation only in such patients in whom the upper end of the growth is well-defined below the aortic arch.

The second case was a female patient, aged forty-six years, in whom I did an external esophagotomy and, at the same sitting, a thoracotomy (Fig. 83)—February, 1919—knowing from palpation at a previously performed gastrostomy, that there was a far-reaching cancerous involvement of the cardia, with infiltration of the glands of the lesser omentum, rendering radical excision impossible. The esophagus was divided about midway between the aortic arch and the cardia, the distal portion inverted and the proximal end transposed under the skin of the chest wall (Fig. 84). As usual, I used immediate air-tight drain-

FIG. 84.—Esophagotomy wound at the neck, closed, the proximal stump healed in place; rubber tube for feeding in gastrostomy fistula.

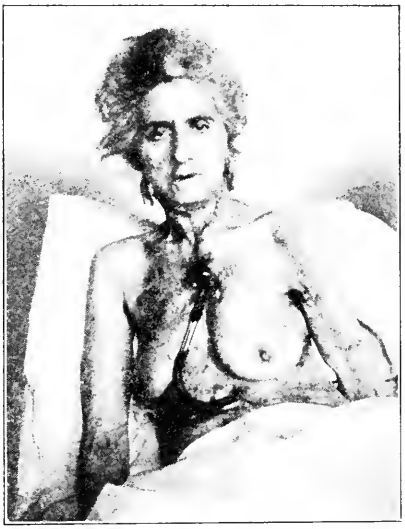


FIG. 85.—Rubber tube in both openings, with connecting glass tube between, through which patient swallowed with ease and without leakage, when gentle pressure was exerted on the upper tube from without, near the opening of the transposed esophagus.

age. The patient, who weighed eighty-nine pounds, stood the operation very nicely; for three days her temperature was entirely normal. Drainage in first eighteen hours = 150 c.c.; in first half of second day = 50 c.c. Then it ceased. On the evening of the third day she commenced to have a slight rise of temperature. To what was it due? If mediastinitis, I was sure, she could not recover. An *x*-ray was taken by the radiologist of our hospital, who reported that there was no trouble in the mediastinum, but that there were distinct signs of pneumonia. Clinical examination soon corroborated this finding. On the thirteenth day after the operation, the patient died under symptoms of advancing pneumonia and with steadily increasing temperature.

However, we had succeeded in giving her back the power of swallowing. The lower end of the transposed esophagus was connected with the gastrostomy opening by a large-sized rubber tube (Fig. 85). Through an interposed glass tube we could nicely watch the swallowed water, milk, soup, etc., being pressed down into the stomach in typical jets by the force of the contracting pharyngeal muscles and the gravity of the food itself.

The patient's easy operative recovery, in spite of her greatly reduced general condition, was due, I believe, principally to the air-tight thoracic drainage, started on the operating table. It was the pneumonia that caused the patient's death; not the operation as such.[1]

In closing this chapter, I desire to reiterate the statement previously made that thoracic surgery is as yet in its very infancy, not the least so the question of the resection of the esophagus for carcinoma. However, the important point is that the thorax, too, is now finally and permanently open to surgery. The further evolution of this subject will and can only come gradually through constant and untiring effort. But the feasibility of the surgical work has been demonstrated. Let us remember that the *site* of the tumor is no longer the determining factor in the question of its operability or inoperability, but the *pathological condition* within the thorax and within the vault of the diaphragm. This condition can be determined only by the palpating hand of the surgeon.

Esophagoplasty—In cases of impermeable cicatricial stenosis of the esophagus the formation of a new tube by plasty has been attempted—esophagoplasty. Several successful operations done on this indication, with excellent and permanent functional result, have been reported within the last few years.

Where the continuity of the esophagus had to be destroyed by resection, the attempt should also be made to restore to the patient the power of deglutition by means of esophagoplasty; and this final object should be kept clearly in mind when planning for the main operation. The new tube formed by plasty may be either partial or total.

Partial Esophagoplasty. *(a) Inferior Partial Esophagoplasty.*—To the various considerations which determine the selection of one of the several methods of gastrostomy in esophageal stenosis, a new one is added in the cases in which an esophagoplasty is contemplated, viz., the bridging of the distance from the opening of the gastric fistula at the stomach to that of the esophageal fistula at the neck or chest. The closer these openings can be brought to each other, the shorter naturally will be the bridge. For purposes of esophagoplasty it is therefore advisable to select a method of gastrostomy which in itself constitutes an

[1] In the third case the tumor again was located behind the aortic arch. The patient's pitiful pleas induced me to go ahead, April, 1920. It was most difficult to arrange to have sufficient length of esophagus left in the vault of the thorax to place and close a purse-string suture after inversion of the esophageal stump, in spite of thorough mobilization of the aortic arch. This greatly reduced patient, too, stood the operation nicely, was soon able to swallow through an interposed rubber and glass tube, but died at the end of the second postoperative week. Wound inspection showed a spontaneous perforation of the esophagus at the "lower" end of the tumor as the immediate cause of death. In its wake had followed advancing fascia necrosis inside and outside of the thorax. (Addition at the time of reading of final proof.)

inferior esophagoplasty and carries the entrance of the stomach from the typical place of a gastric fistula beneath the border of the left costal arch, upward on the chest, in the direction of the left clavicle.

The task has been attempted in various ways. Depage[1] used the lesser curvature, Hirsch[2] the anterior wall of the stomach for this purpose. Beck[3] and Jianu[4] make use of the major curvature of the stomach (Fig. 86) for the creation of a rather long tube, one end of which remains in connection with the gastric fundus, while the other free end is drawn upward.

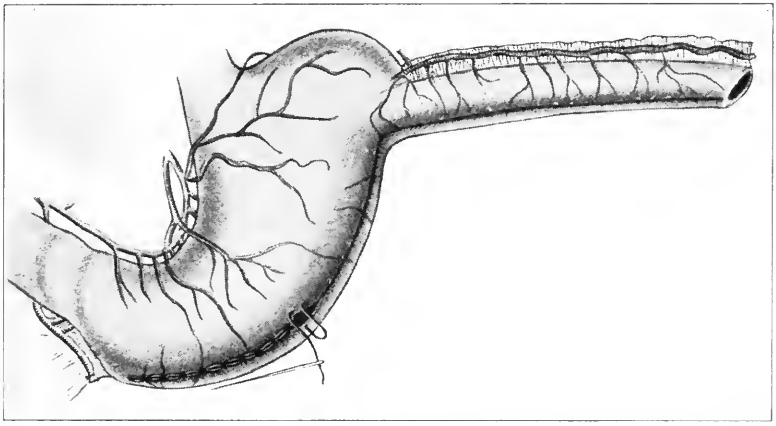


FIG. 86.—The major curvature flap formed into a tube (Beck-Jianu tube) by means of a continuous Connell suture; a second running suture (preferably Cushing's), secures the first row.

Briefly described, the Beck-Jianu operation consists of the following steps: median abdominal incision above the umbilicus; pulling forward of stomach; double ligation and division of part of the major omentum, starting at a spot about 2 inches from the pylorus and ending where the left inferior epiploic artery turns on to the stomach. Ligature of right inferior epiploic artery next to the first omental stump, formed by the ligation, nearest to the pylorus. The stomach wall is now completely bared at this spot (Fig. 87). A mattress suture is then run from here through the entire thickness of the stomach, about $1\frac{1}{2}$ inches distant from and parallel to the greater curvature (Fig. 88, dotted line). The stomach is lifted up by the assistant, so that its contents flow toward the lesser curvature. By the placing of a clamp (better still, of two equally curved clamps), corresponding to the line of the major curvature, the asepsis of this part of the operation is materially improved and the work simplified[5] (Fig. 89). Division of the stomach with scissors right below the suture line (Figs. 88 and 89, heavy line);

[1] Tenth French Surg. Congress, 1903.
[2] Centralbl. f. Chir., 1911, No. 48.
[3] Illinois Med. Jour., 1905, vol. vii.
[4] Deutsch. Ztschr. f. Chir., 1912, cxviii, 383.
[5] If the major curvature is pulled into a straight line by an assistant, a straight clamp will probably do just as well.

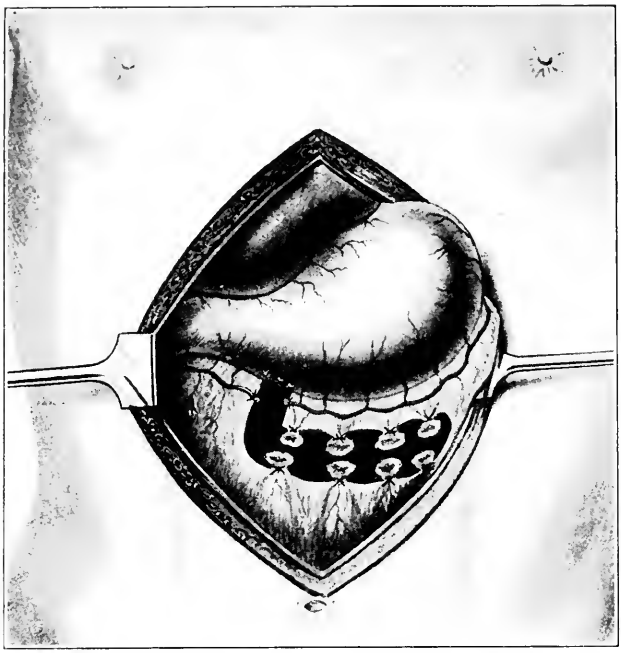


Fig. 87.—Beck-Jianu gastrostomy with inferior esophagoplasty, first step. After longitudinal incision above the umbilicus, double ligation and division of omentum majus up to the point at which the left inferior epiploic artery turns on to the stomach; double ligation and division of right inferior epiploic artery; exposure of major curvature of the stomach.

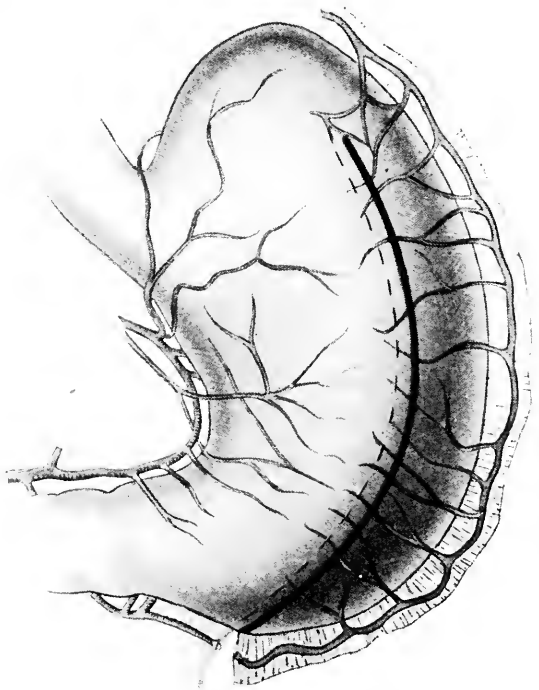


Fig. 88.—A mattress suture (dotted line) divides the lower one-third of the stomach with its major curvature from upper two-thirds; scissors then cut the stomach along the heavy line.

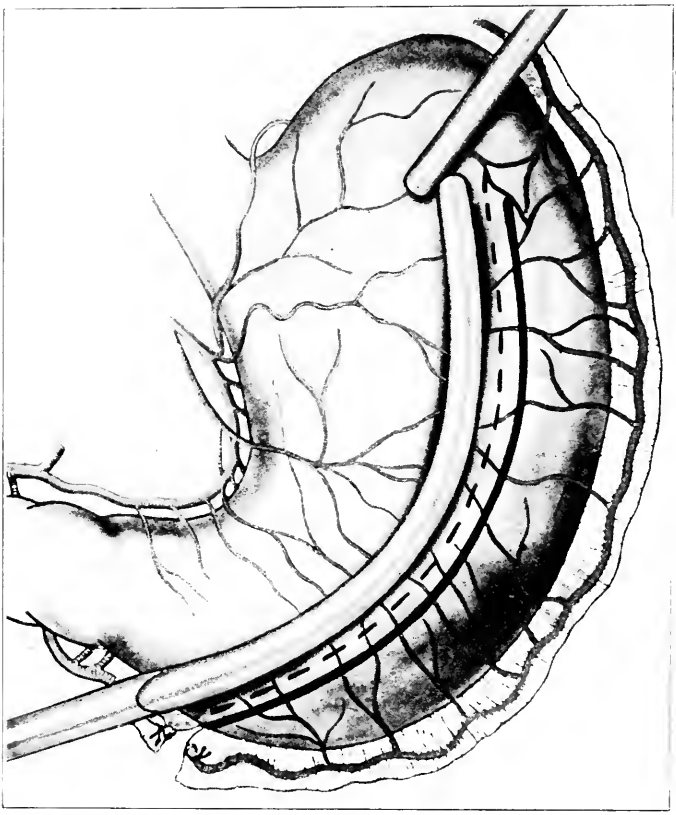


FIG. 89.—By placing a clamp with a curve corresponding to the line of the major curvature this part of the work can be completed and rendered more aseptic. Another straight or bayonet clamp shuts off the communication with the general cavity of the stomach above.

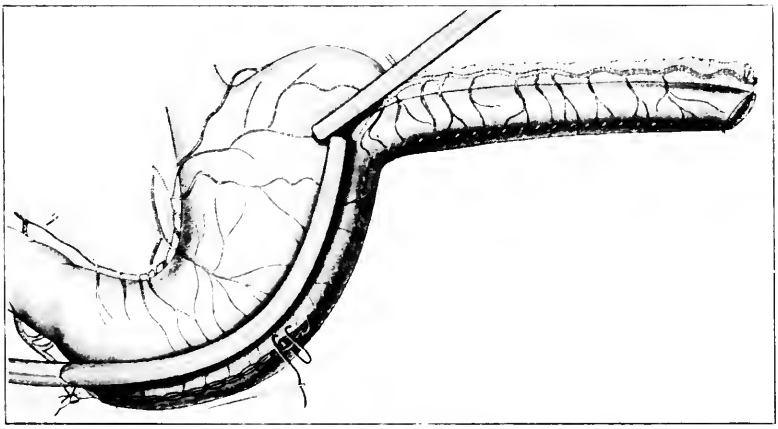


FIG. 90.—The same as Fig. 86, with clamp in place.

then the major curvature is turned up and wrapped temporarily in a piece of sterile gauze: Connell's suture from end of mattress suture to end of stomach flap forms the latter into a tube: "Beck-Jianu tube" (Figs. 86 and 90). A second continuous suture inverts the first one along its entire length. Temporary inversion of end of tube by two or three sutures, their ends being left long (Fig. 91). Stomach turned so that base of the Beck-Jianu tube corresponds to upper angle of abdominal wound, where the base of the tube is secured by a few

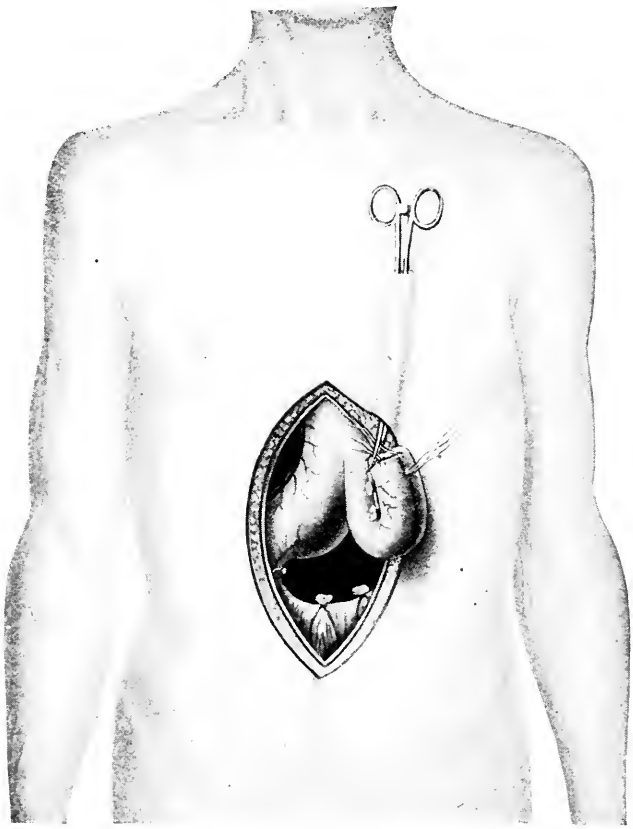


FIG. 91.—Long dressing forceps, entered through a transverse incision, usually above the nipple line, has undermined the skin and grasps the inverting sutures of the outer end of the Beck-Jianu tube in order to pull the latter through this canal upward.

stitches. Closure of lower half of abdominal wound. The tube is placed on the chest to the left of the sternum, to measure its length; horizontal incision in skin of chest at upper end of tube; skin in direction of tube thoroughly undermined and tube pulled up into the funnel with long curved forceps which grasped the end of the inverting sutures (Fig. 91). The latter are then removed, the tip of the tube is everted and the mucosa—*not* the entire thickness of the tube—stitched to the skin at the transverse incision, a strip of gauze is placed in

either angle of the wound for brief drainage (Fig. 92); temporary packing of the orifice of the tube with gauze; closure of upper half of abdominal incision; dressing.

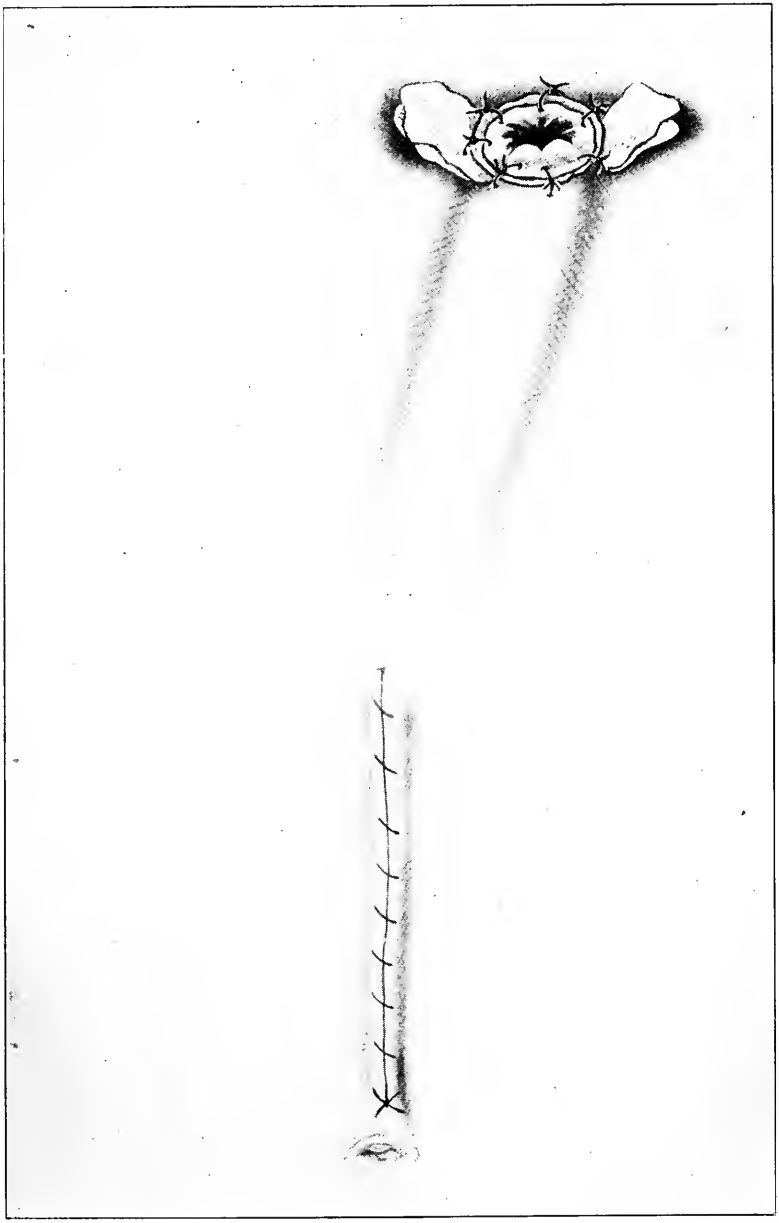


FIG. 92.—Tube pulled through, inverted sutures removed, tip cut transversely and mucous membrane stitched all around to skin; a short strip of gauze introduced at either side of tube for drainage; abdominal wound closed.

A new tube of ample size (18 to 25 cm. in length) with good blood supply, in direct, undisturbed connection with the fundus of the stomach, and surrounded completely by peritoneum has thus been formed.

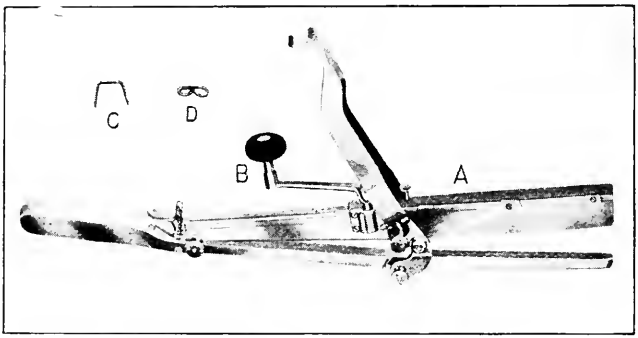


FIG. 93.—Hültl's wire-stitching instrument. *A*, represents the broad, square crushing clamp which harbors the four rows of staples *C*; *B*, shows crank; by turning the same to the right, after the clamp has been closed, the staples are driven entirely through the tissues (wall of stomach or intestines) and their ends bent inward (*D*), having met the resistance of the other branch of the clamp beneath. The bent staples are gradually pushed off in the course of the healing and discharged through the rectum. They do no harm.

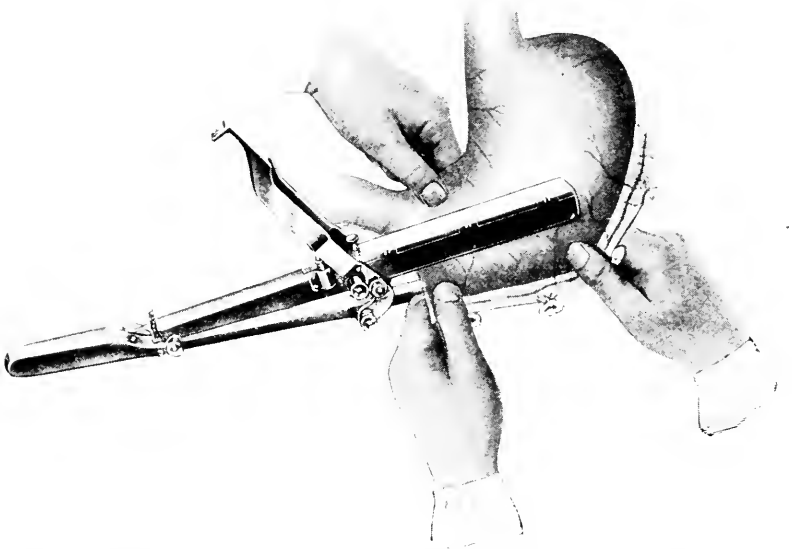


FIG. 94.—Demonstrates the placing of the instrument with the major curvature put on the stretch. The hands at lesser curvature and to the right of major are those of first assistant; the one near the pylorus at major curvature that of the second assistant.

The writer[1] prefers the use of Hültl's wire stitching instruments (Figs. 93, 94 and 95) for detaching the major curvature from the

[1] Meyer, Willy: Ann. Surg., September, 1913; Surg., Gynec. and Obst., February, 1915, p. 162.

stomach. They enable us to render this procedure absolutely dry (Figs. 96 and 97) and, therefore, more aseptic, and also shorten the time of operation, points which are of considerable value in view of the usually greatly reduced general condition of these patients. The earlier functional defects of the new tube have been successfully overcome. The operation may, therefore, be recommended to the earnest attention of all interested in this chapter of surgery.

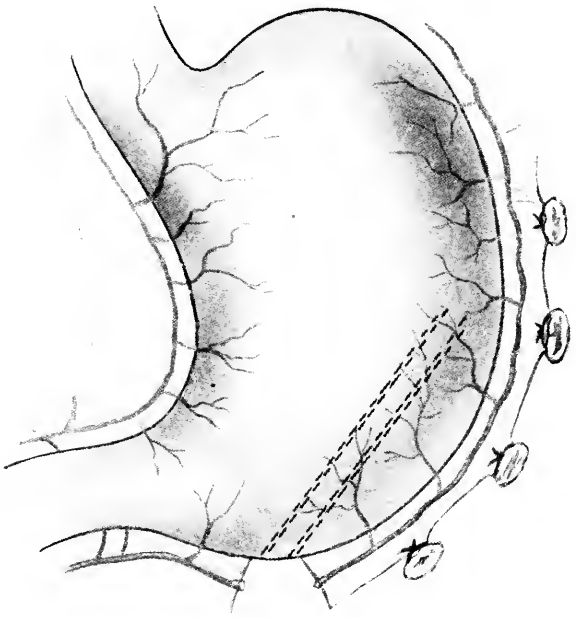


FIG. 95.—Shows the double row of through-and-through wire staple sutures placed; the crushed center portion between the two inner rows is not shown.

An obstacle to its performance is the not infrequently found shrunken condition of the stomach in the presence of a pronounced esophageal stricture of some duration. In a recent case, a man, aged fifty-one years, I found the stomach contracted to the size of the transverse colon. It was technically very difficult to place even a double row of sutures in order to surround a No. 8 French catheter with the stomach wall, after Witzel's method of gastrostomy.

On the other hand, it is remarkable how well the stomach stands the reduction in size by this operation, without functional impairment. In one of my cases, a female patient of twenty-nine years, with advanced esophageal carcinoma, the stomach was reduced to the size of the duodenum by the Beck-Jianu operation. Yet she experienced no digestive trouble during the following months, although she received the ordinary ward fare. The food, having been masticated by the

patient was deposited in some warm fluid and then pressed into the stomach with a syringe through a wide rubber-tube placed in the esophagoplastic canal.

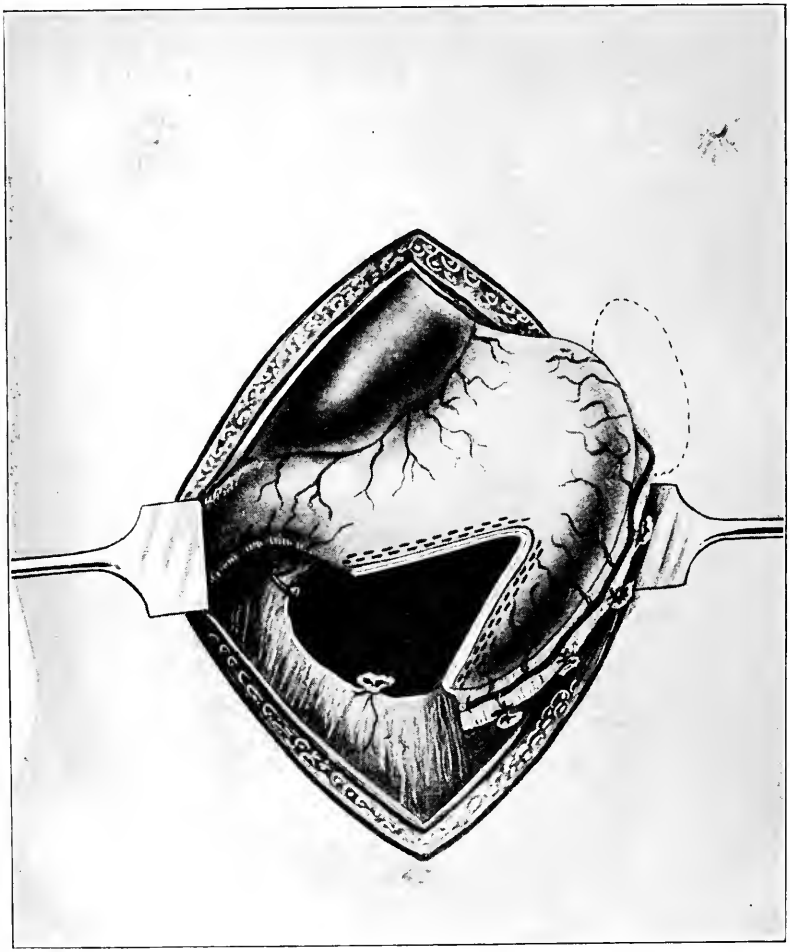


FIG. 96.—Stomach divided between the inner rows of wire staples. The operation is absolutely dry, the tip of the Jianu tube also being firmly closed by the staples.

The writer has performed the Beck-Jianu operation six times without a death (Figs. 98 and 99), making use of needle and thread in the first case and of Hültl's instrument in the remaining five.

(*b*) *Superior Partial Esophagoplasty.*—This consists in the antethoracic and subcutaneous transposition of the esophagus from above downward, as before described. (See Figs. 78 and 84.)

Total Esophagoplasty.—This is a combination of a partial inferior esophagoplasty, according to one of the methods mentioned below

under Nos. 2, 3 and 4, and a partial superior esophagoplasty by the method mentioned in the next paragraph, under 1. In exceptionally favorable cases the addition of method No. 1 can be dispensed with. It would lead too far to describe here the various useful methods worked out by the ingenuity of surgeons. They will be simply enumerated and some parts of them illustrated:

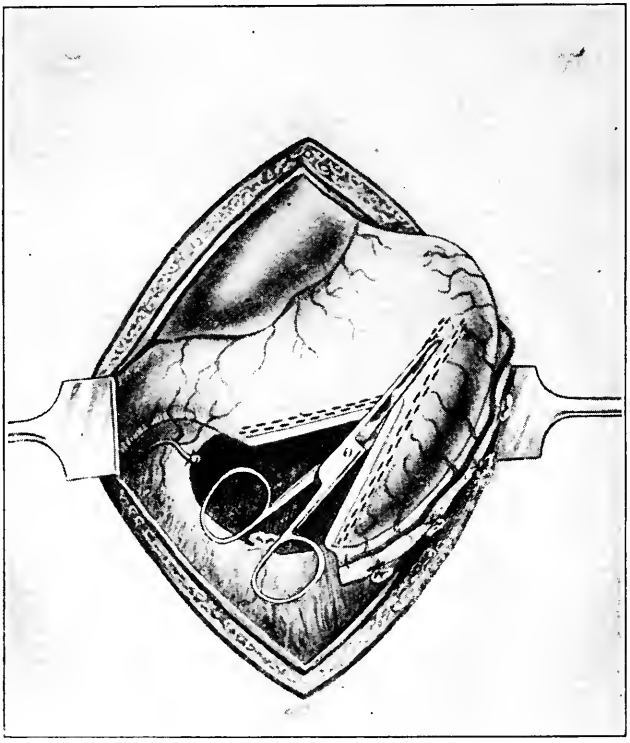


FIG. 97.—A second double row of staples is placed at obtuse angle with Hültl's second (smaller) instrument beyond the turn of the left inferior epiploic artery; scissors traverse the dry crushed center portion between the inner rows.

1. *Esophagoplasty by means of Skin-plasty* (Bircher.[1] This may be total or partial. Bircher, as early as 1894, showed that a well functionating new tube from the neck down to the stomach can be made by plastic work on the skin of the anterior aspect of the thorax.

2. *Inferior Esophagoplasty with the Help of a Totally Excluded Coil of Jejunum* (Wullstein[2]), Roux,[3] Herzen,[4] Lexer,[5] Frangenheim,[6] Rehn,[7]

[1] Centralbl. f. Chir., 1907, No. 5.
[2] Deutsche med. Wchnschr., 1904, No. 20; Centralbl. f. Chir., 1908, No. 8.
[3] Semaine Méd., 1902, No. 1, vol. lv; ibid., 1907, No. 4.
[4] Centralbl. f. Chir., 1908, No. 8.
[5] Centralbl. f. Chir., 1911, Beilage, p. 55; and München. med. Wchnschr., 1911, p. 129.
[6] Wiener med. Wchnschr., 1911, p. 2075.
[7] Esophagus Chirurgie, Jena. G. Fischer, 1914.

Heyrowsky[1], Blaud,[2] Axhausen,[3] and Fromme,[4] have proved the feasibility of the method in cases of intractable cicatricial stricture of the esophagus.

FIG. 98.—Second patient with Beck-Jianu's operation (February, 1913). Venous anesthesia with ether, followed by a severe broncho-pneumonia. Hültl's wire stitching instrument is used. Tube placed subcutaneously, only mucosa stitched to skin at upper opening which is over third costal cartilage; primary union. Base of tube stitched by two sutures to parietal peritoneum at upper angle of abdominal wound in such a way that an angulation of the tube is formed at this place on account of the sinking backward of the stomach into the abdomen. There is very little leakage of stomach contents from the start; a plug of gauze, closing the opening of the Beck-Jianu tube, keeps the patient dry.

FIG. 99.—Showing result of Beck-Jianu's operation in patient with a cancerous stricture in the cervical portion of the esophagus.

[1] Wiener klin. Wchnschr., 1914, No. 4, p. 89.
[2] Beitr. z. klin. Chir., 1916, civ, 46.
Berl. klin. Wchnschr., 1916, No. 3, p. 54.
[4] Beitr. z. klin. Chir., 1919, 1, cv, 222.

Of these authors Blauel had two successful cases, the others one. Ten *successfully completed* cases of this type have so far been reported in the literature.

The esophagus was either divided, its lower end closed and the upper opening united with the skin or it was incised at the neck and its anterior wall drawn forward and stitched to the skin in the shape of a lip fistula. The defect up to the neck from the opening of the inferior esophagoplasty was successfully bridged by a skin-plasty. Axhausen believes that total esophagoplasty can be well done within two to three months in three stages.

First Stage: Total exclusion of the jejunal coil; anastomosis of its lower end with the stomach; subcutaneous transposition upward—formation of lower portion of new esophagus (Fig. 100).

Second Stage: Formation of middle portion of new esophagus by skin-plasty, uniting its lower end with the opening of the transposed jejunal coil.

Third Stage: Esophagostomy; union of esophageal fistula with upper opening of new-formed dermoidal esophagus by means of double skinflap-plasty.

Anatomical examination of the new food passage several years ($2\frac{1}{4}$) after total esophagoplasty, in a case operated upon by Blauel, has proved:

(*a*) The epidermis of the jejuno-skin tube, when examined after several years' use, did not show any pathological changes in consequence of the continuous irrigation with saliva, food and stomach secretion.

(*b*) The lanugo-hair of the skin flaps used for the skin-plasty could not be detected on their surface, and can, therefore, be ruled out as an objection to this method.

(*c*) In order to avoid a stricture between the skin and the jejunal tube, all tension must be strictly avoided. The entire thickness of the jejunal wall should be stitched to the border of the skin, not the mucosa alone.

(*d*) In order to avoid the formation of a fistula, "lateral anastomosis" between the remaining neck portion of the esophagus and the upper end of the skin tube is preferable to division of the esophagus, occlusion of the distal end and end-to-end union between the two tubes.[1]

3. *Inferior esophagoplasty with the help of the totally excluded transverse colon* (Kelling,[2] Vuillet[3] in combination with Bircher's operation). The transverse colon, totally excluded, also represents useful material for the formation of a new extra-thoracic, subcutaneously placed esophagus (Fig. 101). This operation has of late again been carried out with good result by v. Hacker.[4] The remaining defect is always bridged by a skin-plasty, according to Bircher.

[1] Müller, P.: Beitr. z. klin. Chir., 1919, 1. cxviii, 95.
[2] Centralbl. f. Chir., 1913.
[3] Semaine Méd., 1911, No. 45.
[4] Centralbl. f. Chir., 1914.

The plastic work described under two as well as three, requires a series of operations, the first of which always has to be gastrostomy.

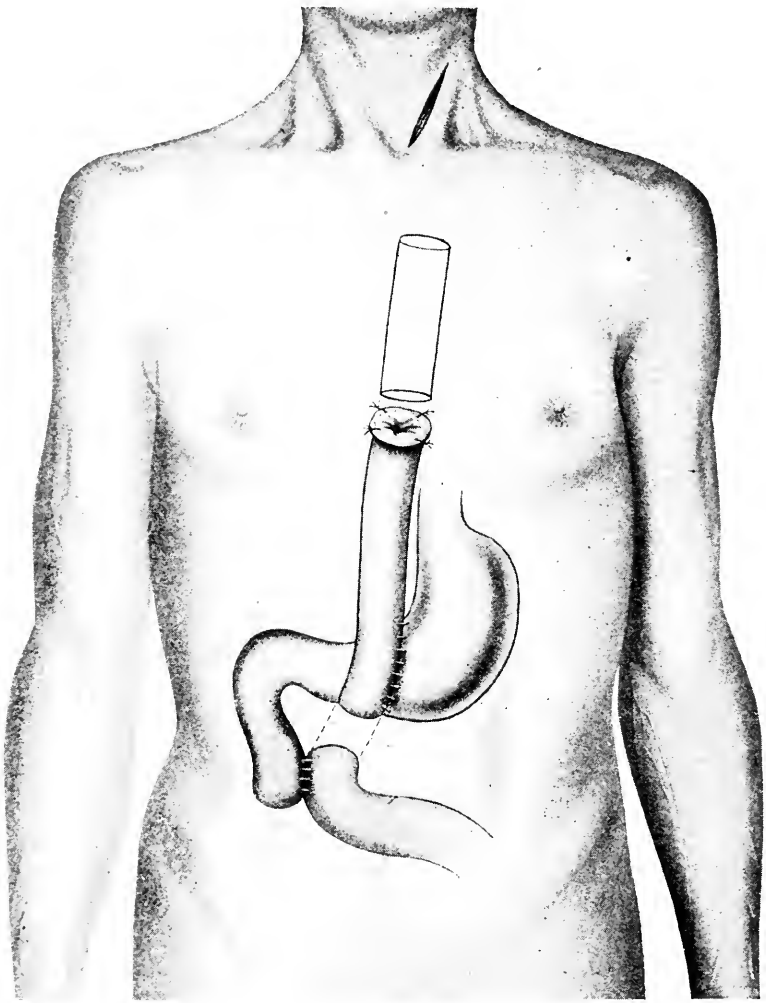


Fig. 100.—Diagrammatic; after illustration in Frangenheim's "Esophagoplastik," l. c. Inferior esophagoplasty with the help of a totally excluded coil of the upper jejunum placed subcutaneously in front of the thorax (Wullstein-Roux operation). A lateral anastomosis unites the jejunal ends; the lower opening of the transposed coil has been joined to the stomach; the upper, which reaches up to the level of the mammillæ, is anastomosed by a skin-plasty with the neck portion of the esophagus.

4. *Inferior esophagoplasty with the help of the dissected portion of the major curvature of the stomach* (Beck-Jianu) described above, in combination with Bircher's operation or with a partial superior esophagoplasty, as represented by the transposed proximal esophageal stump.

The Beck-Jianu method of gastrostomy promises to simplify this part of the work, inasmuch as it provides at the same time for the formation of the lower portion of a new esophagus. The placing of its free end, whether outside or inside of the thorax, decides the location of the new esophagus and additional operative procedures.

FIG. 101.—Inferior esophagoplasty with the help of the totally excluded transverse colon (Kelling-Vulliet operation). Note the excellent blood supply of the transposed portion by the art. coli.

This method bids fair to take the place of the more complicated operations under 2 and 3, in the treatment of malignant strictures, provided the stomach is found of sufficient size, provided further, that clinical observation proves the successful outcome of an additional skin-plasty (Bircher) in the presence of the acid secretion of the Beck-Jianu tube. Lexer considers this outcome very doubtful.

Still the favorable issue of the plastic union of Bircher's new esophagus, made of a double skin-flap, with a gastric fistula as it results from gastrostomy—which has been seen by various surgeons—speaks for the feasibility of the procedure.

Two patients have been successfully operated upon in this way by Lotheissen, of Vienna, in 1914 and 1919, a union having been completed with the neck portion of the esophagus. (Personal communication, dated January, 1920.)

FIG. 102.—Shows the last step of the two-stage operation just described.

Combining Partial Superior and Partial Inferior, Intethoracic Esophagoplasty to Form a Total Esophagoplasty.—In both operations the stumps are on the same anatomical level of tissue layers, and in line. If they are of sufficient length, a typical end-to-end union will produce total esophagoplasty (Fig. 102), an ideal occurrence.

Otherwise, either a skin-plasty according to Bircher, or a rubber tube must bridge the defect (Figs. 78, 85 and 103). By virtue of the contraction of the strong pharyngeal muscles the food is spurted down with

quite some force (see above, under "Palliative operation for cancerous stenosis of the esophagus"), so that it passes through the connecting rubber tube, even one of considerable length, without having to be massaged down by the patient.

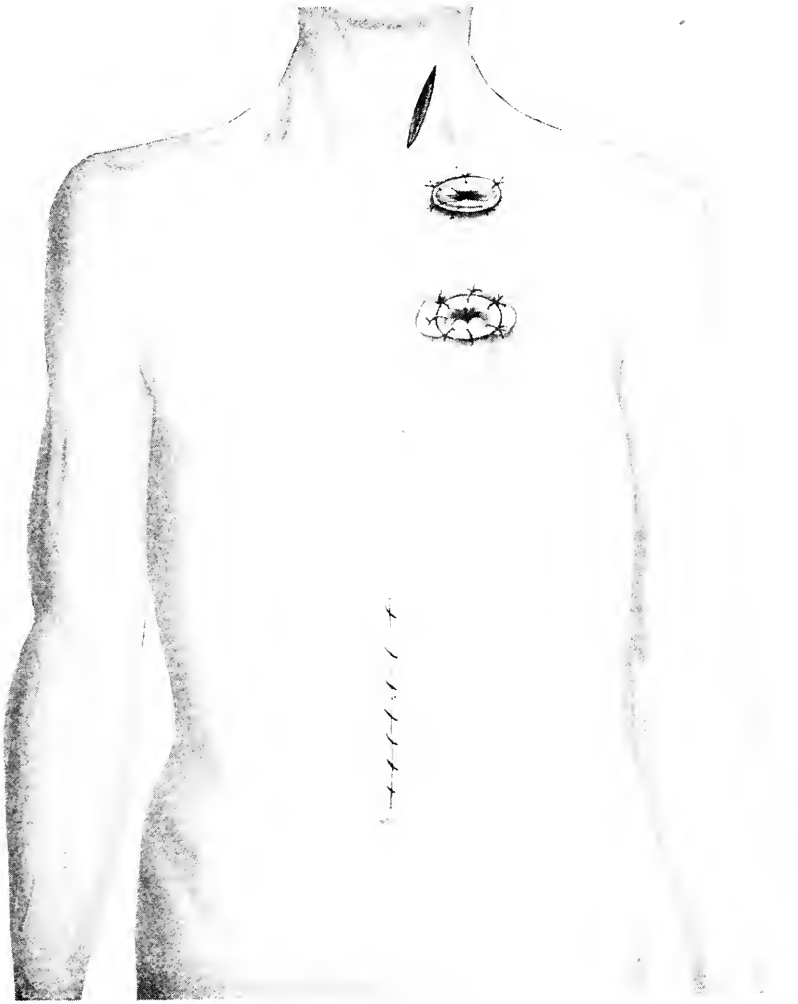


FIG. 103.—Illustrates the condition, if the proximal esophageal stump be too short to meet the opening of the tube pulled up from below. Here the two openings may be united by a rubber tube with a blown-up bulb at its upper extremity, the tube having been drawn downward through the mouth. (Gluck-Perthes method.) If the patient is dissatisfied with such an arrangement a modified skin-plasty according to Bircher is indicated. To insure success of such plastic work regurgitation of food and stomach juices must be reduced to a minimum.

Intrathoracic Esophagoplasty.—It is conceivable that the splendidly nourished Beck-Jianu tube might well be transposed *intrathoracically*

instead of *extrathoracically*, in order to replace the excised portion of the esophagus. In that event the tube would have to be brought up into the pleural cavity through the foramen esophageum, or alongside the cardia—which in that case would have to be closed by sutures, after resection of the tumor—(see Fig. 104) and its free opening to be joined by end-to-end anastomosis to the oral stump of the esophagus, which would thus remain *in situ*, absolutely undisturbed (Fig. 105).

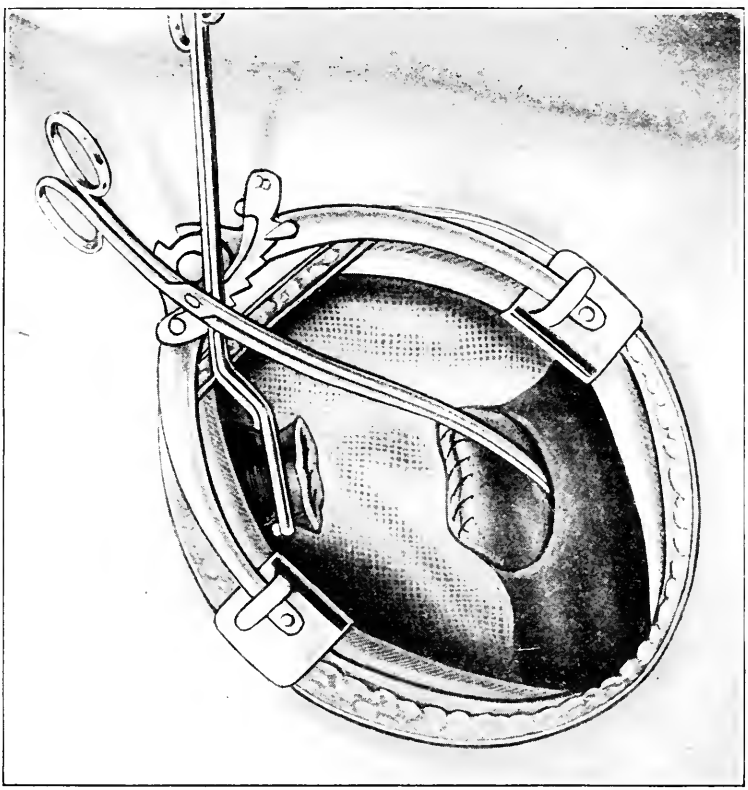


FIG. 104.—Intrathoracic esophagoplasty. After the Beck-Jianu tube has been formed through abdominal incision, as shown in Figs. 96 and 97, patient is turned on right side and thorax opened by an incision in seventh intercostal space; rib-spreader in place; esophagus isolated and tumor excised; clamp occludes proximal end; distal end inverted. Abdominal cavity bluntly entered alongside closed cardia and the temporarily occluded Beck-Jianu tube pulled with a long curved dressing forceps into thorax where it is to replace the excised lower third of esophagus. Care must be taken not to twist the Beck-Jianu tube in the course of this transposition, for which the abdominal wound, which was temporarily clamped, may be re-entered by the surgeon's left hand in order to assist manipulation. Or the abdominal wound can be thoroughly closed by sutures after the long threads at the inverted tip of the Beck-Jianu tube—wrapped in a piece of moist gauze—have been placed right beneath the foramen esophageum of the diaphragm. Practical experience in man must decide which method is preferable.

The drawback of this seemingly ideal procedure is that the entire work would have to be done in one sitting, at least so far as our knowl-

edge goes at present, whereas with extrathoracic esophagoplasty the inferior portion can be formed during the first stage and resection of the esophagus, with transposition of the oral esophageal stump, in the second stage. A patient afflicted with malignant disease will hardly have sufficient power of resistance to stand the operation in one sitting. None of the 6 dogs thus operated on by me experimentally have survived. Ways would have to be worked out experimentally, to make intrathoracic esophagoplasty also a two-stage operation.

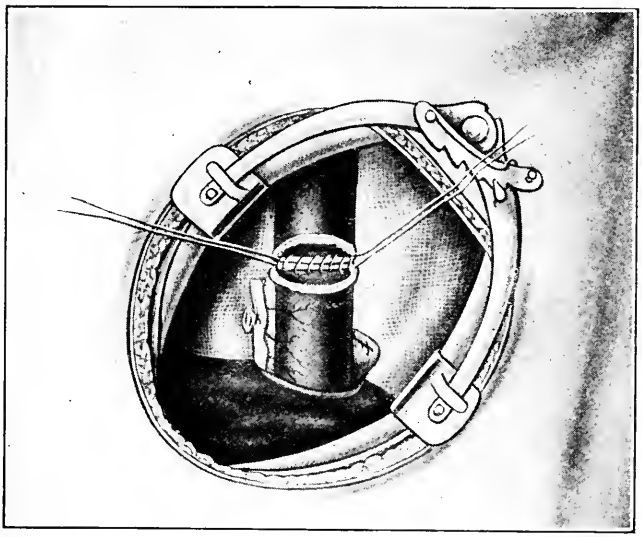


FIG. 105.—The Beck-Jianu tube has been pulled up into the thorax through a hole made in the diaphragm alongside the closed cardia, and is being united to the undisturbed proximal esophageal stump by means of end-to-end anastomosis.

Should further observation in man prove that a transposed oral stump of the esophagus, *no matter how long,* has no tendency to become necrosed in its distal portion, but will live, as a rule, so that "the ideal" end-to-end anastomosis between the inferior and superior esophagoplastic stump could oftener be done *extrathorically,* in that event the mentioned experimental work would be less needed, and *extrathoracic esophagoplasty* would become the operation of choice after resection of a carcinoma in any part of the esophagus.

SURGERY OF THE BREAST.

By ROBERT B. GREENOUGH, M.D.

ANATOMY AND DEVELOPMENT OF THE BREASTS.

The breast of the adult female is a glandular structure situated upon the anterior and lateral aspect of the chest, extending on each side from the third to the seventh rib, and from the sternum to the border of the axilla. The rounded eminence of the breast is composed of the tissue of the mammary gland, with a firm deposit of subcutaneous fat surrounding it on every side. The gland tissue proper is flattened from before backward, and of an irregular lobular shape. It is composed of a series of gland lobules radiating from the nipple. Each main duct branches into many smaller ducts, and these again into a series of bulbous ends which are lined with a double layer of epithelial cells—the acini of the gland.[1] The ducts and acini of one lobule are distinct from those of other lobules. The largest and best defined lobule occupies the upper and outer quadrant of the gland, and extends nearly to the axilla. The gland tissue is supported in a framework of interlobular connective tissue through which pass the bloodvessels, nerves and lymphatics of the breast. The nipple is situated near the center of the breast, and presents the openings of the terminal ducts of the mammary gland, ten to twenty in number. The nipple normally projects above the surface of the breast and is endowed with erectile properties due to the presence of muscle fibers surrounding the ducts and attached to the overlying skin. The nipple is surrounded by the areola, an area of pink or pigmented skin, containing numbers of large sebaceous glands, beneath which there is very little of the subcutaneous fat which underlies the skin in other places.

The bloodvessels of the breast are derived from the internal mammary, intercostal and axillary systems, and the nerves chiefly from the second, third, fourth and fifth intercostal nerves. The lymphatics of the breast are especially rich and of great importance to the surgeon. A superficial, subcutaneous plexus covers the outer surface of the breast, and a dense meshwork of deep lymphatic channels penetrates to all parts of the gland substance, and is continued in the lymphatic trunks of the deep fascia of the chest and abdominal wall. Abundant anastomoses exist between the two systems. The main trunks follow the axillary border of the pectoral muscles, and empty into the lymph nodes of the axillary region, but the mesial portions of the gland are drained to a certain extent by channels which perforate the intercostal

[1] Bizzozero and Ottolengui: Anatomische Ergebnisse, Abth. iv, Bd. ix.

spaces and empty into the nodes of the anterior mediastinum. The superficial axillary nodes under the border of the pectoralis major are those in most direct communication with the breast, and through them the nodes in the axilla, and eventually the subclavicular and supraclavicular nodes are reached. Minute lymph nodes have been found lying under the pectoralis major and in communication with the breast lymphatics by branches which perforate the muscle. Anastomoses exist between the lymphatics of the right and left breasts, across the sternum, and a few communicating branches occasionally carry infection directly across the clavicle to the supraclavicular lymph nodes.[1]

The development of the mammary gland in the embryo takes place by an infolding of the epidermis of the lateral aspect of the chest. In animals which have multiple mammary glands, this infolding of the epidermis occurs in a line extending from the axilla to the groin, the so-called "milk line." The human embryo normally presents but one gland on each side. Supernumerary breasts occur occasionally in the human being, however, and are, as a rule, developed along this "milk line." At birth and during infancy the development of the gland is slight and equal in both sexes. In the male, the development of the gland is rudimentary and rarely advances beyond the infantile stage. In the female, an increase in the size of the breast takes place at the time of puberty, and is due to the development of gland tissue, and to the deposit of fat within and about the gland. One of the characteristic features of the developing breast gland is the hyaline connective tissue which surrounds the gland ducts and develops with them. This tissue contributes to the firm and elastic consistency of the breast and is of importance to the surgeon on account of the fibro-epithelial tumors of the breast in which it frequently takes an important part. Each lobule of the breast gland, composed of the epithelial lined ducts and hyaline periductal tissue, is separated from the adjacent lobule by interlobular connective tissue of the ordinary type, through which run the bloodvessels, lymphatics and nerves of the gland. This interlobular tissue binds all of the breast together, and is prolonged in fibrous tissue strands attaching the organ to the fascia of the chest wall below, and to the skin above. These fibrous attachments to the skin have been called the ligaments of Sir Astley Cooper. It is by their retraction when infiltrated by cancer tissue that the adherence of the skin over the breast is produced—one of the most constant and earliest signs of malignant disease. When pregnancy occurs, a great increase in the development of the gland tissue takes place. The secreting surface becomes greater, new bloodvessels are formed, and the entire organ increases in size and weight, so that it covers a much larger part of the chest wall, extending down even on to the abdomen. When lactation is established this vascularity continues, and the secretion of the epithelial cells is elaborated and discharged as milk. After lactation ceases,

[1] Oelsner: Arch. klin. Chir., 1901, lxiv, 134. Sappey: Traité d'Anatomie descriptive, Paris, 1889, vol. ii and iv.

a certain amount of retrograde change takes place in the gland structure. The organ becomes smaller and less vascular, and much of the newly produced epithelial tissue is replaced by fat; the breasts lose their firm consistency and become more pendulous. At the time of the menopause further retrograde changes occur, the terminal secreting lobules become atrophied, the connective tissue increases in amount and takes on the character of scar tissue. A further deposit of fat in the tissues of the breast generally occurs after the menopause.[1]

MALFORMATIONS OF THE BREAST.

Amazia (*Amastia*).—Amazia denotes absence of the breast; *athelia*, absence of the nipple. These deformities are of great rarity and are generally accompanied by a defect in the development of the pectoral muscles or of the chest wall on the corresponding side. Amazia occurs in males and females with equal frequency.

Micromazia (*Micromastia*).—Micromazia or partial but imperfect development of the breast in the female, is of more common occurrence. It is generally accompanied by defective development of the sexual organs and may affect both breasts or only one.

FIG. 106.—Supernumerary breasts. One supernumerary gland in each axilla, and one in lower portion of left breast. (Massachusetts General Hospital.)

Polymazia (*Polymastia—Polythelia—Pleomastia*).—These are terms used in an indefinite manner to denote the presence of supernumerary breasts or nipples. This abnormality has been noted in many instances, both in the male and in the female. The additional gland or glands are

[1] Greenough and Hartwell: Jour. Med. Research, 1903, iv, 417.

found, as a rule, to occupy a position immediately above or below the normal breast, along the "milk line," from axilla to groin; but aberrant mammary glands are said to have been found in other situations, as upon the thigh (Fig. 106). Supernumerary breasts may equal or even exceed in size the normal breast. Occasionally a nipple is present, and in rare instances milk has been secreted and the function of lactation performed. As a rule, however, the supernumerary gland is imperfect and its removal is to be advised. Two functional nipples upon one mammary gland are occasionally seen, but more frequently a supernumerary nipple is without function. Supernumerary breasts have been thought to be more frequently the seat of new growths than the normal breast. They are frequently mistaken for new growths and are thus of importance from a diagnostic point of view. Their removal by operation is indicated in the majority of cases.

FIG. 107.—Gynecomazia. Definite increase of gland structure of breast in boy aged twenty years. Removed by operation. (J. C. Warren.)

Gynecomazia.—Gynecomazia is a rare malformation and consists in the development of the mammary gland in the male to a degree approaching that which is normal in the adult female (Fig. 107). This condition is occasionally found in cases of hermaphroditism, but is not uncommon in virile males. True gynecomazia must be distinguished from a deposit of fat in the mammary region, which is not at all uncommon in the male, and inflammatory processes and neoplasms of the male breast, though rare, must be excluded in the diagnosis.

INJURIES OF THE BREAST.

Injuries of the breast are less common than might be expected, owing to the protection of clothing and the yielding nature of the part.

Contusions and Hematoma.—Contusions and hematoma of the subcutaneous tissues may occur and blood may be poured out in the substance of the gland itself. Injuries of this nature generally yield to treatment by support and evaporating lotions. Suppuration may occur, however, immediately or at some subsequent time, when infection is admitted to the hematoma directly or through the blood current. A history of preceding contusion can often be obtained in new growths or inflammatory lesions of the breast. The induration left in the tissues by the organization of such an exudate may occasionally present certain difficulties in the diagnosis of new growths, and in such cases exploration by operation is the only safe course to pursue.

Wounds.—Wounds of the breast may be produced as in other organs, and require no special consideration. A penetrating wound of the lactating breast which severs one or more of the larger milk-ducts may result in the production of a *milk fistula*. Such fistulæ are slow to heal during the continuance of lactation, but close readily at its termination. The scar of such a wound may cause obstruction and lead to the formation of a galactocele or milk cyst, at a subsequent lactation, or may produce a simple retention cyst in the intervening period when the breast is not secreting milk.

Foreign Bodies.—Foreign bodies are occasionally introduced into the tissues of the breast by accident or design. Pins and needles are not infrequently driven into the breast by insane women. Foreign bodies in the breast produce symptoms similar to those in other situations, and their removal by operation is indicated.

DISEASES OF THE NIPPLE.

Retraction (Depression or Inversion of the Nipple).—The nipple normally projects somewhat above the surface of the areola in a conical or cylindrical form. The prominence of the nipple is normally increased during pregnancy and lactation. Retraction is present when this prominence is lacking and the nipple cannot be drawn out by the suckling of an infant or by artificial measures. Retraction may be due to developmental defects. It is also produced by the contraction of scars and by the infiltration of malignant tumors, in which case it is significant in diagnosis.

Treatment.—During lactation, retraction of the nipple may prevent nursing and thus lead to serious engorgement of the breast. The breast pump and the suction of the nursing child will relieve the lesser degrees of this affection. In more obstinate cases attempts may be made with plaster or contractile collodion to cause contraction of the areola and maintain the prominence of the nipple. A plastic operation has been recommended by Kehrer for the same purpose by the removal

of crescentic folds of skin above and below the nipple, and Warren has operated upon such cases, with success, by turning up the breast and uniting the tissues beneath the nipple by subcutaneous catgut stitches.

Imperforate Nipple.—Imperforate nipple may occur as a developmental defect or by cicatricial occlusion of the ducts. When lactation occurs in such a case, engorgement results and galactocele or abscess is likely to ensue.

Treatment.—The treatment is that of the resulting condition, and amputation should be performed.

Cracks or Fissures.—Cracks or fissures of the delicate integument of the nipple are readily produced by trauma. The first attempts of the child at suckling are especially prone to bring about this condition, owing to the maceration of the part in the mouth of the child and the congestion which accompanies the beginning of lactation. Fissures produced in this way may be so painful as to prevent nursing altogether, but their importance is far greater than this, for it is through these fissures, in the majority of cases, that the infection is transmitted which produces acute mastitis or abscess of the breast. The treatment of fissures is thus of great importance in the prevention of abscess.

Treatment.—Fissures are to be treated with mild antiseptic washes, such as boric acid, and scrupulous cleanliness is to be maintained. As a rule, nursing should be abandoned on the affected side and the breast emptied periodically by massage or the breast pump. During the establishment of lactation, scrupulous cleanliness and washing with boiled water before and after nursing, will tend to prevent the formation of fissures, and should be strongly recommended as a prophylactic at the commencement of lactation.

Fissures of the nipple may occur at other times than during lactation. They may be produced by trauma or uncleanliness, and are not uncommon in eczema of the nipple. Fissure of the nipple may also occur as a primary manifestation of syphilis.

Eczema.—Eczema of the nipple may occur during pregnancy as well as during lactation, when it is produced by lack of cleanliness and is favored by the maceration of the skin in the fluids escaping from the lacteal ducts. The skin is red and thickened and crust formation occurs.

Treatment.—Eczema of this form is generally relieved by soothing applications and by cleanliness. It may, however, result in the formation of a fissure, and thus favor infection and acute mastitis.

Paget's Disease.—A peculiar form of eczema of the nipple which has been the subject of much investigation and many controversies, is that described in 1874 by Sir James Paget and now known generally as "Paget's Disease of the Nipple." Its most significant characteristic is its connection with cancer of the breast. Paget's disease occurs independent of lactation, and, indeed, its cause is as yet unknown. It attacks the breasts of women of adult and mature age and produces a characteristic lesion. The nipple, areola and after the lapse of some months often the greater portion of the cutaneous surface of the breast,

present a raw, red, moist surface of irregular outline, covered here and there with crusts of exudate and flakes of dried-up epidermis. The appearance was likened by Paget to that of an acute balanitis —a most striking simile. In advanced cases the nipple may be entirely eroded. The eczematous condition persists and spreads and no medicinal applications appear to affect its progress. The course of the disease may continue for several years, until sooner or later a nodule of cancer is found in the substance of the breast tissue.

Pathology.—The pathology of one type of Paget's disease has been well established as a form of very superficial epidermoid cancer of the same general character as rodent ulcer. Thickening of the epidermis, prolongation of the papillæ and intense, round-cell infiltration of the cutis are the characteristics of the histology of the disease. The columns of epidermal cells infiltrate the subcutaneous tissues, and in the late stages of the disease involve the ducts of the mammary gland, thus producing an epidermoid cancer of the breast.

In other cases of Paget's disease, however, cancer of glandular origin develops in the deeper portions of the breast, and by extension to the deeper layers of the skin produces an infiltration which leads to destruction of the skin and ulceration similar in appearance to the epidermoid type of Paget's disease. In still other cases the relation between eczema of the nipple and gland cancer of the breast may be impossible to determine, although the two conditions may be coincident.

Diagnosis.—The diagnosis of Paget's disease of the nipple depends upon its characteristic appearance. No other condition can be mistaken for it, unless perhaps the eczema of lactation, which can be readily distinguished by its occurrence during lactation and its ready disappearance under simple treatment.

Prognosis.—The prognosis, with operation, is, as a rule, more favorable than in the average case of cancer of the breast, but depends always upon the extent and duration of the disease and upon the type of cancer present. The epidermoid type of cancer in itself is less malignant than glandular carcinoma of the ordinary form.

Treatment.—The treatment of Paget's disease of the nipple is by operation—the amputation of the breast. The "complete operation" for cancer of the breast should be performed as in other cases of cancer. *X*-rays and radium have been employed successfully for the treatment of the eczema, but the important condition is the predisposition to cancer, and for this reason amputation should always be performed.

Tumors of the Nipple.—New growths originating in the nipple are extremely rare. A number of different forms of fibro-epithelial tumors have been described, and it is noteworthy that almost all tumors of this origin assume a rounded, pendulous form, with the production of a slender pedicle. Papillary tumors of fibro-epithelial type (papillary cystadenoma or the villous papillomata of English writers[1]) which arise in the extremities of the lacteal sinuses, occasionally develop

[1] Shield: Diseases of the Breast, 1898, London, McMillan & Co.

outward with the production of a tumor of the nipple. The projection of fungous papillary masses from the lacteal ducts may occur in certain cases and produce a tumor on the surface of the nipple resembling exuberant granulations.

The treatment of tumors of the nipple is by excision, but amputation of the breast may be indicated if the whole of the nipple is to be excised.

DISEASES OF THE BREAST.

The diseases of the breast may be divided into: (1) functional diseases; (2) inflammatory processes; (3) cysts and cystic disease; and (4) new growths.

Functional Diseases of the Breast.

The process of lactation may present a number of abnormal variations.

It may occur, though rarely, independent of pregnancy, and it is said to have been performed by the breast of the male.

Abnormalities of the milk are occasionally noted, such as a blue, red or yellow color, due to bacterial invasion of the ducts. Biliary coloring matters may appear in the milk, and a number of drugs are thus secreted.[1] Vicarious menstruation is said to be evidenced by the periodical discharge of blood from the nipple. This condition is often simulated, however, by certain papillary tumors in the gland ducts, which bleed more readily at the time of the catamenia because of the increased congestion of the breast.

Mastodynia (*Neuralgia—Irritable Mamma—Hysterical Breast*).—Neurotic conditions of the breast are by no means rare. Mastodynia, or pain in the breast, may occur in individuals with a neurotic taint, independent of obvious pathological conditions. In such cases abnormalities of the genital organs are not infrequently observed. Pain in the breast of a degree out of all proportion to the diseased condition is also found accompanying certain pathological conditions. Cases of chronic cystic mastitis and of diffuse hypertrophy of the breast not infrequently present this symptom. The pain may extend down the arm of the affected side by involvement of the intercostohumeral nerve. When pregnancy occurs the sensitiveness of the breast may be such as to prevent nursing.

Treatment.—The treatment of neurotic conditions of the breast is general and symptomatic and the neurasthenic condition of the patient is to be met with appropriate treatment. Any associated genital disorder should be corrected and pathological conditions of the breast itself, if present, should be relieved. A supporting bandage often relieves pain to a great extent, but local applications are to be avoided. Tumors of the form described as neuromata, or painful fibromata, such as occur in other situations, are occasionally found in the sub-

[1] Bizzozero and Ottolenghi: Anatomische Ergebnisse, Abth. iv, Bd. ix.

cutaneous tissues overlying the breast, and may cause extreme pain, simulating mastodynia. The treatment of neuromata is by excision.

Atrophy.—Atrophy of the breast is the normal condition after the menopause. As a rule, atrophy of the glandular elements in women just past middle life is compensated by an increase in the fatty tissue of the breast, and no marked diminution in the size of the organ can be determined. In spare individuals, however, and in those of advanced age the breast is markedly atrophied in size. Atrophy of the breast has been attributed to acute mastitis occurring in infancy or at puberty, in certain cases, or as a result of the mastitis of mumps. This condition very rarely follows operative removal of the ovaries in earlier life. There is no treatment. It is worthy of note that a disparity in size between the two breasts is of very ordinary occurrence, and that in function, also, during lactation one breast often far exceeds the other in the amount of milk secreted.

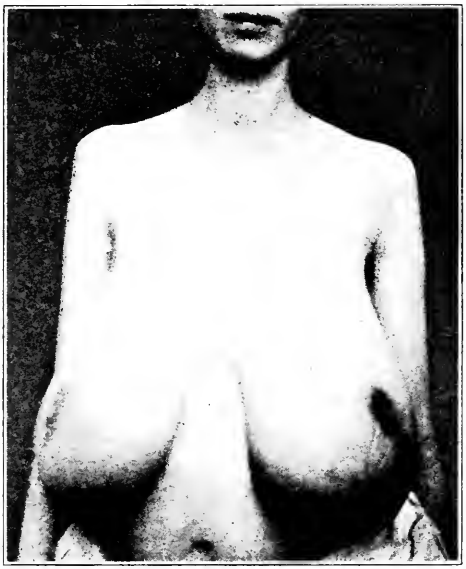


FIG. 108.—Diffuse hypertrophy of breast (pregnancy). (Massachusetts General Hospital.)

Hypertrophy (*Diffuse Hypertrophy*).—The most marked increase in the size of the breast occurs normally at puberty, and during pregnancy and lactation. Increase in the size of the breast beyond the normal limits, and to such an extent as to embarrass the health and comfort of the patient, is known as diffuse hypertrophy of the breast (Fig. 108). It is of rare occurrence. The pathological condition consists of a diffuse increase of all the elements of the breast: gland tissue, fat, and fibrous tissue—the fibrous tissue being, as a rule, most markedly involved. Some writers are inclined to regard the extreme cases of breast hypertrophy as an actual new growth, of the nature of a fibro-epithelial tumor. Hypertrophy of the breast occurs most frequently

in pregnancy, and progresses with great rapidity until its termination. The function of lactation may be deficient. A diminution in the size of the breast may be expected after lactation is ended, but the breast remains of abnormal size and is almost certain to undergo further hypertrophy in succeeding pregnancies. Hypertrophy of the breast in young girls at the age of puberty is occasionally seen, and is often accompanied by mastodynia. In such cases genital abnormalities of structure or function are not uncommon. The pathological condition is the same as in the cases which develop during pregnancy, but the size of the breasts is rarely so excessive. In C. B. Porter's case, a woman, aged thirty-seven years, the combined weight of the two breasts after amputation was sixty pounds.[1] Enlargement of one breast alone, in younger women, is more often due to a fibro-epithelial tumor than to diffuse hypertrophy. In tropical countries the breast is occasionally affected in a manner similar to the leg or scrotum by filarial disease. A condition of elephantiasis or lymphangiectasis of the breast is thus produced, which is distinguished from true hypertrophy by the limitation of the pathological changes to the skin and subcutaneous tissues. The disease is extremely rare.

Diagnosis.—In diagnosis extreme cases of diffuse hypertrophy are not likely to be confused with any other condition. Cases of less degree of development and cases affecting one breast alone must be distinguished from cysts and from the fibro-epithelial tumors. The diffuse nature of the growth in hypertrophy and the absence of a localized, encapsulated tumor must be relied upon to distinguish the condition.

Prognosis. The prognosis of diffuse hypertrophy of the breast is for a slow but continuous increase in size. If pregnancy intervenes a rapid development may be expected. Partial remissions may occur, but in well-marked cases the disease is progressive. The nature of the growth, however, is benign and a malignant metamorphosis of the tissues is improbable.

Treatment.—The treatment of well-marked cases of diffuse hypertrophy of the breast is by operation. Amputation of the breast may be done in the ordinary manner. A tourniquet, held by Wyeth's pins, was used by Porter in one classical case to compress the pedicle, as in amputation of the hip. In cases of bilateral hypertrophy both breasts may be amputated simultaneously or an interval of time may be allowed to elapse between the two operations. The lesser degrees of hypertrophy demand only supporting bandages and general constitutional treatment. Applications, massage and manipulation are to be strenuously avoided. Pelvic disorders when present should be corrected.

Infantile Hypertrophy.—Early development of the mammary gland in female children is not uncommon. Cases have been recorded of marked development of the breasts, together with growth of pubic

[1] Porter: Boston Med. and Surg. Jour., March 3, 1892; Tr. Am. Surg. Assn., 1891, vol. ix.

hair, at between two and three years of age. As a rule the other sexual organs share with the breast in the precocious development.[1]

Inflammatory Diseases of the Breast.

Acute Mastitis.—Acute inflammation of the breast may occur at several different periods in the development of the gland. At birth, at the age of puberty, and during pregnancy and lactation, the development of the breast is rapid, and is accompanied by an increased vascularity and tumefaction or engorgement, which especially favor the development of infective organisms. This infection is introduced, in the vast majority of cases, through neglected fissures of the nipple, and as these fissures are especially frequent during lactation, and as this is the period when vascular engorgement of the breast is most pronounced, acute mastitis of the puerperal breast is by far the most common form.

Fig. 109.—Acute mastitis of infants. Abscess. (Case of Dr. James S. Stone, Infants' Hospital, Boston, Mass.)

Mastitis Neonatorum.—In the newborn, swelling of the breast and the escape from the nipple of a few drops of milky fluid ("witches' milk") is not infrequently observed. The breast is swollen, red and tender. Infection may readily occur through injury to the delicate skin of the nipple, or especially by manipulation, a method of treatment much favored by ignorant midwives (Fig. 109). The inflammation rarely progresses to actual abscess formation. Scrupulous cleanliness,

[1] Bryant: Diseases of the Breast, 1887. London, Cassell & Co.

washing the part with sterile water or dilute alcohol, and a light protective covering will generally avoid infection and allow the process to subside. Should an abscess form it is to be opened and drained as in other situations. The injury to the breast produced by this condition cannot be correctly estimated. It has been thought to predispose to inflammatory processes or tumor formation in later life.

Mastitis of Puberty.—At the age of puberty a marked development of the breast takes place in the female, and inflammatory conditions occasionally result. In the male, also, congestion and tumefaction of the gland at this time may occur. Swelling and tenderness are not uncommon. In rare cases infection and suppuration may occur, and treatment by incision may be necessary.

Puerperal Mastitis (*Breast Abscess*—"*Broken Breast*").—This condition is of common occurrence even at the present day, although its cause is generally understood and its prevention clearly indicated. By far the greater number of cases of acute mastitis occur during lactation, and in the period from the fourth to the eighth week after labor the breast appears to be specially predisposed to this disease.

Milk Engorgement.—During the first week after childbirth, when the function of lactation is beginning, and at later periods, when the periodical emptying of the breast is interrupted either by the death of the child or its inability to suckle or by any other reason, a collection of the products of secretion in the gland lobules may occur, causing "milk engorgement"—a distention of the gland and "caking" of the breast, with swelling, tenderness and even a rise of temperature. This condition predisposes to an acute mastitis and affords a favorable culture medium for infective organisms, which readily find entrance through the fissures in the nipple and areola, which are so commonly observed in nursing women. Whether infection occurs through the ducts themselves, in the absence of fissures, has been disputed. In the vast majority of cases infection occurs by way of the lymphatics from a fissure of the nipple. Engorgement is not always primary but may occur as a secondary process and be due to the blocking of the ducts by the products of infective inflammation. The exact onset of infection is not always readily distinguished.

Acute mastitis of the puerperal breast is frequently ushered in by a chill and a marked rise of temperature. The breast becomes enlarged and heavy. Pain and tenderness are marked and the skin assumes a dusky red color. Constitutional disturbances may be extreme or may be of slight extent, depending on the severity of the infection.

Abscess.—The staphylococcus is the organism most frequently present in abscess of the breast, but streptococci occasionally find entrance and produce a grave form of infection. Other bacteria are rarely found. One breast is commonly affected, but both breasts may be involved. As a result of acute mastitis, abscess formation is the rule. When abscess does not occur the process has been one of engorgement only, or the invading bacteria have not been of sufficient virulence to overcome the resistance of the patient. The abscess may be purely

superficial and involve only the subcutaneous surface of the gland and overlying tissues, especially in the region of the areola, or it may begin in a deep lying segment of the gland and involve a large area before reaching the surface. A lobular distribution of infection is not uncommon, one main duct and its branches being obstructed and later undergoing abscess formation. The abscess cavity in deep abscesses is almost always divided into many compartments by strands of fibrous septa which have resisted the suppuration more vigorously than the intervening tissues. Hour-glass or "shirt-stud" forms of abscess are not uncommon. An unusual but grave event is the rupture of an abscess into the retromammary space, and its extension between the pectoral fascia and the gland. Extension of the abscess cavity to the surface generally occurs, but much time and great destruction of tissue may be avoided by early recognition and evacuation (Fig. 110).

FIG. 110.—Breast abscess. Multiple incisions and drainage, showing destruction of breast tissue. (Massachusetts General Hospital.)

Diagnosis.—The diagnosis of abscess is confirmed by the detection of fluctuation. When deeply seated, however, an ill-defined sense of elasticity may be all that is obtained by palpation. In these cases it is rare that differing areas of consistency cannot be detected, suggesting a crater-like softening in the middle of an area of greater induration.

The superficial areolar abscesses heal promptly on evacuation. The prognosis of the deep breast abscess in the majority of cases is also good. Death rarely occurs by exhaustion, septicemia or pyemia. The

prognosis for satisfactory lactation at a later pregnancy is dubious, and in a certain number of cases recurrence of the abscess, chronic inflammatory processes, and rarely the development of a new growth at a later date may be anticipated.

Treatment.—The treatment of acute mastitis should be its prophylaxis. Scrupulous care and cleanliness during the establishment and maintenance of lactation should be observed. Cold water and dilute alcohol washes during the latter part of pregnancy will increase the resistance of the skin of the nipple. Inverted and distorted nipples should be corrected by gentle manipulation, and in extreme cases, by operation. After childbirth the nipple should be washed with boiled water before and after nursing, and boracic acid ointment or a simple mild antiseptic should be applied. A fissure once detected should receive energetic treatment until entirely healed.

Engorgement of the breast is best relieved by a supporting bandage, restriction of liquid diet, mild purgation, and the removal of the excess of secretion by massage or with a sterile breast-pump. Massage is undoubtedly the method most to be preferred, but should be practiced with the utmost gentleness and cleanliness. When abscess of the breast is present, operative treatment is at once required. The preservation of the function of the breast demands interference at the earliest possible moment after the diagnosis is reasonably certain. More breasts are sacrificed by dilatory treatment than are injured by too early incision. On account of the multilocular character of abscesses of the breast, two or more incisions are needed, as a rule, to ensure drainage. Radical incisions, with the patient under an anesthetic, and abundant irrigation are demanded. When the abscess is pointing in the upper portion of the breast, a small incision may be made in this situation, and counter incisions of 10 to 15 cm. in length may then be made at the lower and axillary margin of the breast to secure dependent drainage. All incisions unless following the thoracomammary fold, should be made in a direction radiating from the nipple, in order to avoid injury to the gland ducts. Incisions should not traverse the areola of the breast when it is possible to avoid this region. A generous incision following the lower and outer border of the breast is the most satisfactory, especially when a small counter incision above provides through-and-through drainage. The patient should be placed in a semi-recumbent position and the wound packed with rubber "protective" wicks. The operative treatment of abscess of the breast is of great importance, but its successful issue depends largely upon constitutional and hygienic measures which should never be neglected. Saline purges should be given, and the amount of liquids ingested reduced to a minimum. Nursing with the affected breast is practically impossible on account of pain, but should be forbidden, under any circumstances, in the interest of the child as well as of the mother. Nursing with the other breast should, in all but the mildest cases, be abandoned also, in order to facilitate the termination of lactation. Engorgement of the other breast should be relieved by massage, and areas of engorgement

in the uninfected portions of the affected breast should be reduced by the gentlest massage. A tight supporting bandage to both breasts should be applied. Constitutional remedies, such as iron and malt, are frequently indicated. Painstaking and energetic prosecution of the after-care and dressing of the wound yield prompt and satisfactory results, but with neglect relapse and extension of the infective process is not infrequent. Palliative treatment of this condition by external applications or by puncture and aspiration of the abscess, or the instillation of carbolic solution, have not met with general acceptance, although the passive hyperemia treatment of Bier, by suction, is an undoubted aid in the after-treatment when adequate surgical drainage has been obtained.

Mastitis of Mumps.—In common with the ovary and the testicle the breast is peculiarly liable to an acute inflammatory process in the course of an infectious parotitis. Girls between twelve and twenty are most liable to this affection, and its frequency varies in different epidemics. Whether due to an actual bacterial infection or to the toxins derived from infection in other regions, cannot be stated. Inasmuch as suppuration almost never occurs, the latter hypothesis seems more probable. The breast is swollen, hard, and tender, and an elevated temperature is common. Movement of the arm may be painful, and a supporting bandage is indicated. Abscess formation is extremely rare, and the process generally subsides in the course of a few days. Atrophy of the breast or lack of further development may result, and the loss of function in later life may be of importance.

Abscess of the breast resulting from acute mastitis has been discussed in the preceding paragraphs. *Abscesses of the breast produced by other causes* are occasionally observed, but are very rare. Abscesses may involve the breast by extension from the chest wall beneath, as in necrosis of the ribs, or empyema. Abscess may result, also, from trauma and hematoma in the mammary region, and in this connection the frequent selection of the subpectoral region for subcutaneous infusion should be borne in mind.

Chronic Inflammatory Diseases of the Breast.

Syphilis.—Syphilis may involve the breast, both in its primary and in its later manifestations. Chancre of the breast is unusual, but a number of cases have been reported. The usual manner of infection is that of the wet-nurse by a syphilitic child. The primary lesion is generally situated upon or at the base of the nipple and presents an atypical fissure or ulceration, one-half to one inch in diameter, with indurated edges and grayish-yellow base. The absence of pain is a conspicuous feature, and the indolence of the lesion is marked. Involvement of the axillary glands and, later, secondary symptoms confirm the diagnosis. Secondary eruptions in the form of papules, macules and pustules appear upon the skin of the breast, and mucus patches may be produced in the fold under a dependent breast, by maceration.

Late syphilis affects the breast but rarely, either as a gummatous nodule or a diffuse induration. Gumma is the more common form and appears as a large, hard nodule, with discolored skin and rapidly softening center. The diffuse form of infiltration, though extremely rare, is not unlike other forms of chronic mastitis, and the diagnosis will depend upon other evidences of syphilis and the effects of treatment. Both forms yield promptly to the use of specific treatment. A lack of development, or even atrophy of the breast, has been noted as a great rarity in cases of hereditary syphilis.

Tuberculosis.—Tuberculosis is probably the most common of the chronic inflammatory conditions of the breast, due to specific forms of infection. Compared with chronic cystic disease and tumors, however, it is of rare occurrence. Infection of the breast tissue may rarely occur

FIG. 111.—Tuberculosis of breast. Retrograde infection from axillary glands. Treated by excision of outer upper quadrant with preservation of breast. (R. B. Greenough, Massachusetts General Hospital.)

through skin lesions near the nipple or by way of the ducts. In the majority of cases, however, infection occurs by direct extension from tuberculosis of the ribs or pleura or is brought by the blood or lymph channels from foci of tuberculosis in other parts of the body. Primary tuberculosis of the breast is certainly an unusual condition. The disease is most common in young women, and pregnancy and lactation appear to predispose to the condition in the presence of tuberculosis elsewhere in the body (Fig. 111). The disease may appear in a diffuse form, involving large areas of breast tissue, or multiple tuberculous nodules may appear scattered through the breast. A cold abscess may be formed by fusion and caseation of the tuberculous tissue or the skin may be early involved, and sinuses produced with characteristic pale granulations and thin puriform discharge. Typical giant cells are less

common than in other forms of tuberculosis, but they occur in many cases, and the inoculation of suspected tissue in guinea-pigs will always settle the pathological diagnosis. The identification of the bacilli in stained sections is extremely difficult.

Diagnosis.—Clinically, tuberculosis of the breast is to be distinguished from chronic cystic mastitis, other forms of chronic inflammation of the breast and new growths. The diagnosis may be suggested by the varied consistency of the indurated mass, its irregular outline and by the early and extensive involvement of the axillary glands, which is characteristic of tuberculosis. The constitutional symptoms of tuberculosis and the presence of disease elsewhere in the body, will be of assistance. Advanced cases, with sinus formation and involvement of the axillary glands, present less difficulty. The presence of tuberculosis and carcinoma in the same breast has been noted in a number of cases sufficient to deserve mention.

Treatment.—The best treatment of tuberculosis of the breast is removal of the breast and of the axillary glands, combined with the constitutional treatment and hygiene so necessary in all tuberculosis. Palliative treatment alone is indicated when the evidence of tuberculosis elsewhere in the body is such as to lead to no hope of delaying the fatal issue. Under these circumstances, incision, curetting and iodoform or iodin applications may be employed.

Actinomycosis.—Infection of the breast with actinomyces is a rare condition, especially in America. It occurs, as a rule, by extension from the pleura and ribs, and is thus but a part of a far more serious disease. The resemblance to tuberculosis is marked, but the disease is even more chronic in nature and the induration more pronounced. Multiple sinuses are produced from which is discharged a thin pus showing the characteristic sulphur granules.

Treatment.—The treatment is by removal of the infected area *in toto* or by laying open and curetting the sinuses and the administration of potassium iodide. The prognosis depends upon the extent of the infection elsewhere than in the breast.

Echinococcus.—Hydatids of the breast are of extreme rarity, and in America are almost unknown. They are commonly conveyed to the breast by extension from the lung and pleura, and there produce the large encapsulated cyst filled with daughter cysts, which is characteristic of the disease. Suppuration is the ultimate result in the majority of cases and the diagnosis from cysts of other origin is rarely made before this occurs. The treatment is by incision and curetting or by excision of the entire mass. A recent aid to the diagnosis of echinococcus is the complement-fixation test.

Chronic Mastitis.—Chronic inflammatory processes occurring in the breast, and due to other causes than the specific microörganisms, have been variously described by many writers under the general name of "Chronic Mastitis." The most common variety of this condition accompanies the condition to be described under the heading of Cystic Disease of the Breast or Chronic Cystic Mastitis. Chronic

mastitis independent of cystic disease is comparatively rare, and is the result, as a rule, of a previous acute or subacute mastitis or of trauma. One or more lobules of the breast are tender and painful and present a thickened and indurated consistency on palpation. They occur most often after lactation and especially when engorgement or sudden cessation of lactation has provided favorable conditions for infection from the ducts. The pathology of the process is an increase of fibrous tissue, with round cell infiltration along the ducts of one or more lobules of the gland. Periductal mastitis of Delbet.[1] Maladie Noueuse (Phocas).

Minute abscesses may occur and even the condition commonly described as "chronic abscess." In these cases a chronic induration of the breast tissue is found of irregular outline, and the presence of an abscess is rarely recognized. Operation is frequently advised under a diagnosis of new growth, and only after excision is it discovered that the indurated fibrous tissue surrounds an abscess of small extent with thick or even inspissated contents. A form of chronic abscess described by French writers is said to affect the large ducts of the breast, without extension to the surrounding tissues.

A number of cases of chronic inflammatory disease of the breast following lactation have come to the attention of the writer in which the ductal origin of the infection is almost certain. In these cases the ducts of one or more lobules of the breast present foci or suppuration, suggesting strongly the appearances of a bronchopneumonia in the lung. Other writers have described this condition as "mastitis obliterans."[2] All of these conditions, however, are very rare.

Diagnosis.—The diagnosis of chronic abscess of the breast can be made only by exclusion of tuberculosis, gumma, actinomycosis and new growths, and is rarely achieved before an exploratory incision has been made. In the absence of abscesses no definite tumor is produced and the condition is of minor importance unless cystic disease develops. The treatment of the minor cases should be by supporting bandages. Applications are rarely beneficial. The more extensive cases require exploratory incision and operative treatment according to the condition present.

A form of chronic mastitis occurs occasionally in young unmarried women, similar to the postlactation form, but of less extent. Such cases are often accompanied by mastodynia, and tenderness and pain, especially at the time of the catamenia, may be excessive. Trauma is found to be responsible for certain cases of this nature, and continued applications and manipulation are often effective in prolonging or increasing the affection. The neurotic element is strong in many such cases. The treatment is hygienic, and supporting dressings or strapping of the breast may be employed. The disease may be of long duration, but operative interference is rarely necessary, unless in extreme cases, to confirm or establish a diagnosis.

[1] Bulletin de Soc. d'Anat., January, 1893, Paris.
[2] Hörz: Beitr. z. klin. Chir., Tübingen, 1910, lxx, 682–694.

Cysts of the Breast.

The tendency to the formation of cysts is a conspicuous feature of many of the diseases and new growths of the breast. This is due to the distribution throughout the breast tissue of epithelial ducts which are readily obstructed by disease. Rapidly growing solid tumors of the breast, however, may develop cysts by reason of the rapid liquefaction of their tissues which accompanies degeneration, and cysts of this nature are discussed under the section on tumors of the breast.

Cysts due to *obstruction of the ducts* of the breast assume a variety of forms according to the development and function of the breast at the time of their appearance. Retention cysts of the breast are single or multiple. *Single cysts* (evolution cysts—Gross[1]) are rare, and occur, as a rule, in young adults. Obstruction to one of the gland ducts is the usual cause and may be produced by the contraction of scar tissue after trauma or inflammatory process. Cysts of this nature rarely exceed the size of a hen's egg; they are commonly thin-walled and contain a thin, yellowish or brownish fluid. They are not painful or adherent to the skin; suppuration rarely results, and the development of malignant disease in a single cyst in early life is extremely rare. Discharge from the nipple rarely occurs with spontaneous diminution in the size of the cyst.

Galactocele.—A galactocele is a simple cyst of the breast containing milk. It occurs generally during, or at some period after the puerperal state. The milky contents of a galactocele become progressively thicker as time progresses, and the more fluid portions are absorbed, and in this way creamy or oily contents may be obtained and later substances resembling butter or soap. In cases of very long duration even calcareous concretions have been found. The origin of the obstruction to the duct which produces a galactocele is, as a rule, traumatic or inflammatory, although instances of malignant disease causing obstruction of ducts have been recorded. The cicatrix of a healed breast abscess is not uncommonly at fault.

Treatment.—The treatment of a galactocele should be by incision and drainage of the cavity, or by excision of the affected segment of the gland.

Cystic Disease of the Breast (*Chronic Cystic Mastitis—Abnormal Involution* (Warren). *Senile Parenchymatous Hypertrophy* (Bloodgood). *Cystadenoma Mammæ* (Schimmelbusch). *Maladie de Reclus.*[2] With the decline of the development and function of the breast at the time of the menopause a progressive atrophy of the gland elements and

[1] Tumors of the Mammary Gland, 1880, Philadelphia.

[2] Bertels: Deutsch. Ztschr f. Chir., 1913, cxxiv, 9–46; Bloodgood, Joseph C.: Surg., Gynec. and Obst., 1906, No. 6, iii, 721–730; Greenough and Hartwell: Jour. Med. Research, 1903, iv, 417; Koenig: Centralbl. f. Chir., 1893, xx, 49; McCarthy: Surg., Gynec. and Obst., 1913, vol. xvii, also 1914, xviii, 284; Müller, G. P.: Ann. Surg., 1914, lx, 595–600; Greenough and Simmons: Ann. Surg., July, 1914; Jopson, Speese and White: Ann. Surg., November, 1908; Tietze: Ztschr. f. Chir., 1900, lvi, 512; Speese, John: Ann. Surg., 1912, lv, 212; Sasse: Arch. f. klin. Chir. 1 897, liv, 1.

increases of its fibrous components normally occur (Figs. 112 and 113). An exaggeration or abnormality of the process sufficient to cause

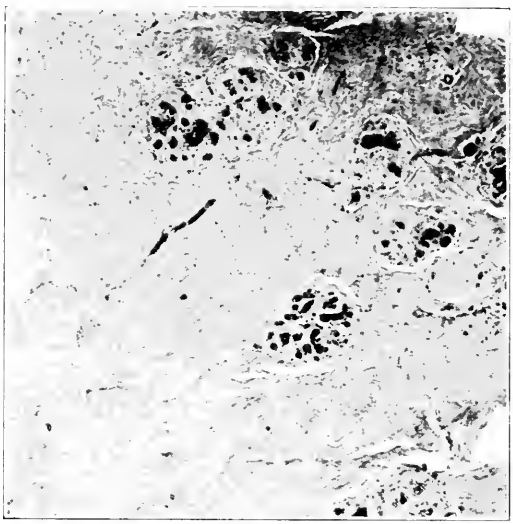


FIG. 112.—Cystic disease of breast. Area of dense fibrous tissue with atrophic gland tubules. (Greenough and Hartwell, Jour. Med. Research, June, 1903.)

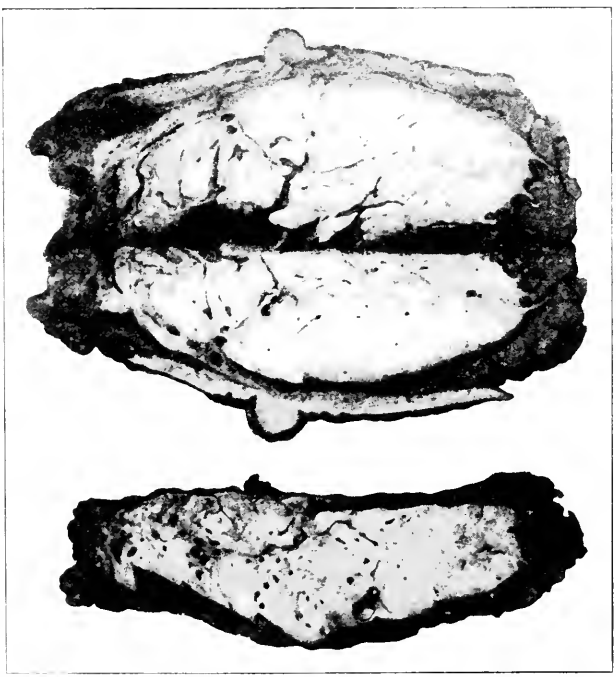


FIG. 113.—Cystic disease of breast. Dense fibrous tissue with multiple small cysts and active proliferation. (J. C. Warren, Am. Jour. Med. Sc., April, 1907.)

palpable induration, pain or cyst formation is called *chronic cystic mastitis* or *cystic disease of the breast.* The lesser degrees of this disease are extremely common, although they rarely give rise to symptoms, and more advanced forms are not infrequent. Cystic disease of the breast was well described by Paget and by Brodie, but was first differentiated as a pathological entity by Reclus in 1883. There has been much discussion as to whether the process was to be regarded as

FIG. 114.—Cystic disease of breast. Fibrous tissue increase with large cysts. (J. C. Warren, Am. Jour. Med. Sc., April, 1907.)

an inflammatory process or a new growth, but it is now generally accepted that the process is primarily a fibrous tissue increase by which the epithelial tissues of the gland are placed under abnormal conditions, such that cyst formation and proliferation of the epithelium takes place, the ultimate and most advanced type of which is adenocarcinoma (Figs. 114 and 115).

Cystic disease of the breast occurs, as a rule, at about the time of, or shortly before the menopause. Single and married women are both

susceptible to the disease, and normal lactation does not predispose to its occurrence. Interrupted lactation or abnormal conditions in the puerperal breast appear to favor the disease. Trauma occasionally appears to influence the onset of this condition. Infection, and auto-intoxication of intestinal origin, though regarded as of primary significance by certain writers, are probably only very rarely important factors. The main factor in the development of cystic disease of the breast appears to be an interruption or irregularity in the normal process of atrophy of the gland. The exciting cause of this interruption cannot be authoritatively stated.

The changes produced in the breast by cystic disease are of very great variety, both in character and extent. A small portion of the breast or the whole gland may be involved, and often both breasts are

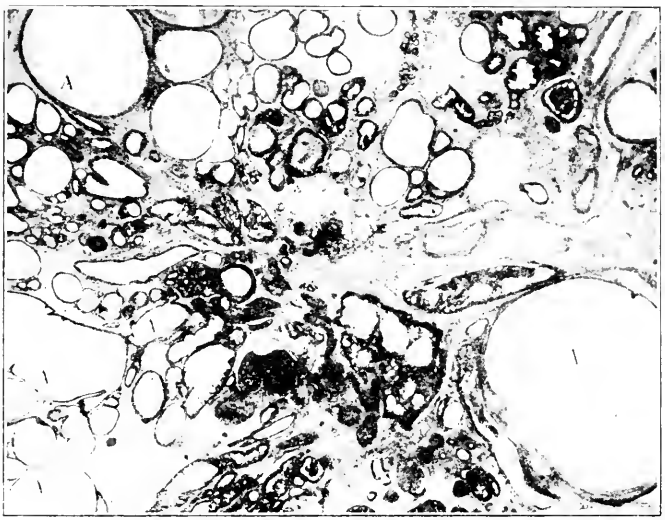


Fig. 115.—Cystic disease of breast with adenocarcinoma. (J. C. Warren, Am. Jour. Med. Sc., April, 1907.)

similarly affected, though rarely to the same degree. A mass is formed of greater consistency than that of the normal breast, and a nodular or "cobblestone" feeling is often to be appreciated. These conditions are produced by the increase of fibrous tissue and the presence of cysts which are characteristic of the disease, and which are shown by section of the gland. The cysts are more abundant, as a rule, on its pectoral surface. Cysts of all sizes may be found, from those of microscopic size to cysts 8 to 10 cm. in diameter, or even larger. The contents of the cysts vary greatly in color and consistency, but a viscid fluid of greenish or brownish tint most commonly occurs. Microscopically, dense fibrous tissue and cysts of all sizes are found, together with the remains of the epithelial ducts of the atrophying gland. The epithelium of the ducts and cysts may present all degrees of proliferation, and it is the

epithelial tissues which give the variety to the histological picture and indicate the degree of advance of the disease. Advanced cases present the types of epithelial growth characteristic of cystadenoma, and it is possible that they should indeed be regarded as actual new growths.[1] (Schimmelbusch.) The important feature of the disease, however, is the occurrence of cancer in a considerable percentage of cases (10 to 15 per cent.). The figures vary in different observations, but the occurrence of cancer in a certain percentage is widely accepted. The symptoms of cystic disease of the breast present considerable variation. One or more indurations appear in the breast of a woman who is approaching the menopause. Attention is drawn to this either by accident, or because of pain of a lancinating character, which often involves the shoulder and arm as well as the breast itself (mastodynia). The indurated mass may involve a single lobule of the breast, often the upper and outer quadrant, or the whole gland, and, indeed, both breasts may present the characteristic scattered foci of induration of a nodular character. The borders of the induration are generally ill-defined, but cysts of 2 or 3 cm. in diameter can often be diagnosed by the elastic, rounded tumor they produce. Increase in the size of this induration, and greater sensitiveness are commonly present at the time of catamenia, and the discharge of a small amount of yellowish or brownish fluid from the nipple may occur, when the cysts lie near the central portion of the gland, with the diminution or disappearance of one or more of the rounded nodules. The skin is not adherent, and the breast is freely movable upon the muscles. Slight enlargement of the axillary lymph nodes is not uncommon.

The progress of the disease is variable. In many cases a slow advance is to be observed, extending over a number of years. Rarely spontaneous subsidence of the symptoms occurs, either with or without treatment, and the induration remains permanently without increase. As a rule, an increase in the process is to be expected, with involvement of other portions of the gland or of the other breast. In a certain number of cases the advance of the disease is accompanied by extreme proliferation of the epithelium of the cysts and the development of carcinoma. Such cases are difficult to differentiate before the actual symptoms of carcinoma are presented. The diagnosis of cystic disease of the breast must be made by exclusion and practically all of the other diseases of the breast must be considered. The presence of multiple cysts of the breast, as indicated by the nodular elastic feeling, the indefinite outline, the disseminated areas of induration often involving both breasts, the discharge from the nipple when present, the pain and tenderness, the slow progress without involvement of the skin or axillary glands—all are features which favor the diagnosis of cystic disease and are against carcinoma. It must never be forgotten, how-

[1] Bloodgood, Joseph C.: Am. Jour. Med. Sc., February, 1908. Speese, John: Malignant Degeneration of Benign Tumors of the Breast, Ann. Surg., 1910, li, 212. Schimmelbusch: Arch. f. klin. Chir., 1892, xliv, 117; Zeitschr. f. Chir., 1900, lvi, 512.

ever, that areas of carcinoma may occur in the center of the induration of cystic disease of the breast, and in no case of this disease, other than that of the earliest and most insignificant degree, can a malignant growth be with certainty excluded. The fibro-epithelial tumors of younger women are rarely mistaken for cystic disease. Subacute and chronic mastitis after lactation may generally be diagnosed by the history of a preceding acute mastitis. Tuberculosis, syphilis, actinomycosis and other chronic inflammations, present their own special characteristics and rarely confuse the diagnosis.

Treatment.—The treatment of chronic cystic disease of the breast is mainly by operation. In younger women, non-operative or palliative treatment is often advisable. Lesser degrees of the affection may often be relieved of symptoms by the use of a breast supporter. The administration of potassium iodide in 10-grain doses, three times a day, has been recommended. Local applications and massage should be

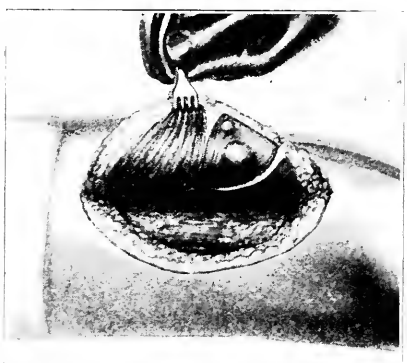


FIG. 116.—The Warren "plastic resection," showing the axillary incision and the breast turned back for the removal of a pie-shaped segment containing cysts. (J. C. Warren, Ann. Surg., June, 1907.)

avoided, and in every case the utmost vigilance should be employed to observe the further course of the disease. An increase of the process while under treatment is indication sufficient for operation, and advanced cases involving more than a single quadrant of the gland, in older women, should be operated upon at once. In extensive cases, excision of the whole gland may be necessary; this may be done by amputation or by subcutaneous excision beneath the skin, after the method advocated by Warren. The lesser degrees of the disease in younger women may be excised by the plastic resection method of Warren (Fig. 116). An incision is made in the furrow below and to the outer side of the breast, circumscribing the gland from near the axilla to just within the nipple line, and the whole breast is then reflected toward the opposite shoulder and its pectoral surface dissected free from the chest wall.[1] Examination of the posterior surface of the

[1] Gaillard, Thomas T.: New York Med. Jour., 1882.

gland can now be made, and the diseased segment excised in the form of a V, with its apex toward the nipple. A few buried sutures bring the remaining surfaces together and the breast is turned back into position, and the skin wound closed with sutures. By this method the entire glandular structure can be excised without removal of the nipple, and the subcutaneous tissues and fat drawn together by sutures to simulate the rounded swelling of the normal breast. In the after-treatment of these operations a form of dressing which supports the breast without undue compression is required. A return of the disease in cases of complete excision is impossible except in the other breast. When partial excision is done, the portions of the gland remaining may give rise to further disease. This occurred in 8 of 83 cases collected by the writer.

Cysts Due to New Growths.—The cysts which are produced by tumors of the breast are of great variety, and will be discussed in the section allotted to tumors of the breast. The tumors which are specially notable on account of their cystic character, and which must be borne in mind in the diagnosis of any breast lesion which is accompanied by cyst formation, are the papillary cystadenoma, cystic sarcoma, and cancer cysts.

TUMORS OF THE BREAST.

Tumors of the breast have long excited the interest of surgeons and pathologists. They are very common and they occur in great variety. Carcinoma is more common in the mammary gland than in any other organ of the female except the uterus, and in this fact lies the extreme importance of the correct diagnosis of tumors of the breast. For clinical purposes it is important to divide the tumors of the breast into two classes—benign and malignant. Benign tumors are, as a rule, encapsulated. They do not infiltrate the surrounding tissues, and when removed they do not recur. Malignant tumors are not encapsulated. They show a tendency to infiltration of surrounding tissues and to extension to more distant parts. This tendency to extension often prevents the complete removal of the disease by operation, and post-operative recurrence of the growth is not uncommon.

The division of breast tumors into benign and malignant forms is a purely arbitrary one and cannot invariably be made to correspond exactly with the microscopic examination of breast tumors after removal. It must be admitted, also, that certain tumors which in their early stages are essentially benign in character may show a tendency to develop into malignant tumors as they progress. In the main, however, the distinction between benign and malignant tumors is one of great importance to the surgeon in determining the proper treatment of a given tumor.

In the section on the Anatomy and Development of the Breast it was seen that the gland is made up of a system of epithelial-lined ducts supported in a connective-tissue framework. The intimate relation

of these elements is such that any new growth in one of them affects the other to a greater or less extent. Tumors composed entirely of connective tissue, without change in the epithelium of the ducts, and tumors made up entirely of epithelium without a connective-tissue participation, are practically unknown in the mammary gland.

Classification.—The pathological classification of tumors of the breast has reference especially to the tissue of origin and the histological character of the tumor cells. The classification in most general use today is that of Ribbert.[1] Ribbert describes, under the term "fibro-epithelial tumors," that group of tumors in the breast and salivary glands, the bladder and in some other regions which are made up of epithelial gland elements with a fibrous tissue stroma. These are the tumors arising in the gland tissue of the breast—the so-called *indigenous* breast tumors. The non-indigenous tumors of the breast form a small group of tumors which may rise in the mammary gland as in other portions of the body, but are in no way peculiar to the gland, and, in fact, present no features by which they are to be distinguished from similar tumors in other situations. The grouping of the indigenous breast tumors under the main heading of fibro-epithelial tumors is satisfactory from the pathological point of view, but fails, to a certain extent, to recognize the distinction between benign and malignant characteristics which is important to the clinician. For that reason many attempts have been made to classify these tumors of the fibro-epithelial group for more accurate study. The best of these classifications is that of Warren,[2] which divides fibro-epithelial tumors into two main types—the fibrous type and the epithelial type. This classification and nomenclature will be used in the succeeding description. An effort will be made, nevertheless, to indicate the terms which have been used in medical literature to describe similar tumors. Warren's classification is as follows:

- BREAST TUMORS
  - *Indigenous*
    - 1. Fibro-epithelial tumors
      - *a.* Fibrous type
        - Periductal fibroma.
        - Periductal myxoma.
        - Periductal sarcoma.
      - *b.* Epithelial type
        - Papillary cyst adenoma.
        - Fibro-cyst adenoma.
    - 2. Carcinoma
      - Medullary
      - Scirrhus
      - Adenocarcinoma
      - Colloid
      - Paget's disease
      - Cancer cysts.
  - *Non-indigenous*
    - Lipoma
    - Enchondroma
    - Angioma
    - Lymphangioma
    - Neurofibroma
    - Dermoid cysts
    - Sarcoma

[1] Ribbert: Deutsch. med. Wchnschr., 1905, xxxi, 1219; also Lehrbuch der Pathologischen Histologie, 1896, Bonn, Friedrich Cohen.

[2] Jour. Am. Med. Assn., 1905, xiv, 160; also International Text-book of Surgery, 1900, vol. ii, chapter viii; Am. Jour. Med. Sc., April, 1907.

Fibro-epithelial Tumors of the Fibrous Type.

Periductal Fibroma (*Synonyms:* Adenofibroma, Fibro-adenoma, Fibromyxoma, Intracanalicular Papillary Fibroma, Cystic Fibroma).[1] —These tumors are of common occurrence and make their appearance, as a rule, in the early period of the life-history of the breast—from the age of puberty to twenty-five years or thereabouts. They are rounded, nodular tumors, often multiple, and occasionally disseminated through both breasts, and their most constant feature is their complete encapsulation (Fig. 117). They are not adherent to the skin and underlying tissues and can be slipped about under the skin from one place to another. On section these tumors show a glistening fibrous surface, cut up into irregular patterns by the branching and irregular clefts produced by the distorted epithelial ducts of the gland (Fig. 118). In

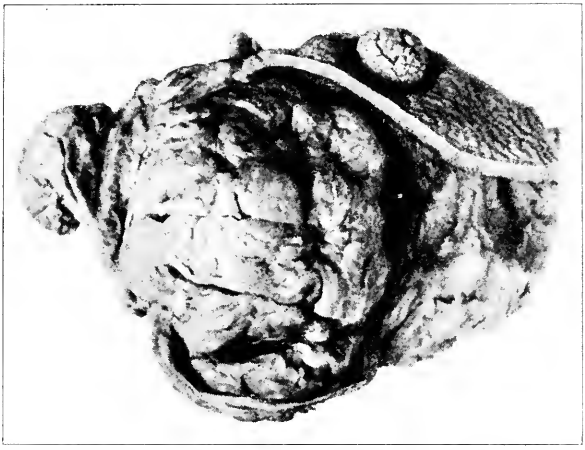


FIG. 117.—Periductal fibroma of breast. Intracanalicular type, showing encapsulated tumor. (Warren Museum, Harvard Medical School. Greenough and Simmons, October, 1911.)

the section on the anatomy and development of the breast reference was made to the peculiar hyaline connective tissue surrounding the ducts of the virgin breast. It is this "periductal" tissue which makes up the bulk of the periductal fibroma and gives it its name.

Periductal fibromata, like the tumors of ovarian and testicular origin, appear to owe their development to embryonic rests (Cohnheim) of gland-producing tissue which have awakened only late in life to active growth and thus failed to fulfil their original purpose but remain without function as a foreign element in the otherwise normal gland. The ducts of a periductal fibroma do not communicate with the other ducts of the gland, and, though during pregnancy and lactation the tumor may share in the general enlargement and vascularity of the breast, its secretion is abnormal and does not reach the nipple, although an

[1] Bertels: Deutsch. f. Chir., 1913, cxxiv, 9–46.

accumulation in cysts in the tumor may take place. Periductal fibromata have a general tendency to increase slowly in size. Sometimes this increase is irregular and intermittent. Rarely a rapid increase in size occurs, due either to an accumulation of fluid in one of the cyst spaces of the tumor or to the development of sarcoma or myxosarcoma in the connective-tissue portions of the tumor. The complete encapsulation of these tumors leads in certain instances to interference with its blood supply. A degree of venous obstruction sufficient to produce edema of the fibrous tissue is a common event and the histological picture of such a case leads often to the diagnosis of myxoma. More rarely degenerative phenomena occur from insufficient circulation, and in one case which came under the writer's observation, gangrene of the tumor took place within the capsule from obliteration of its blood supply.

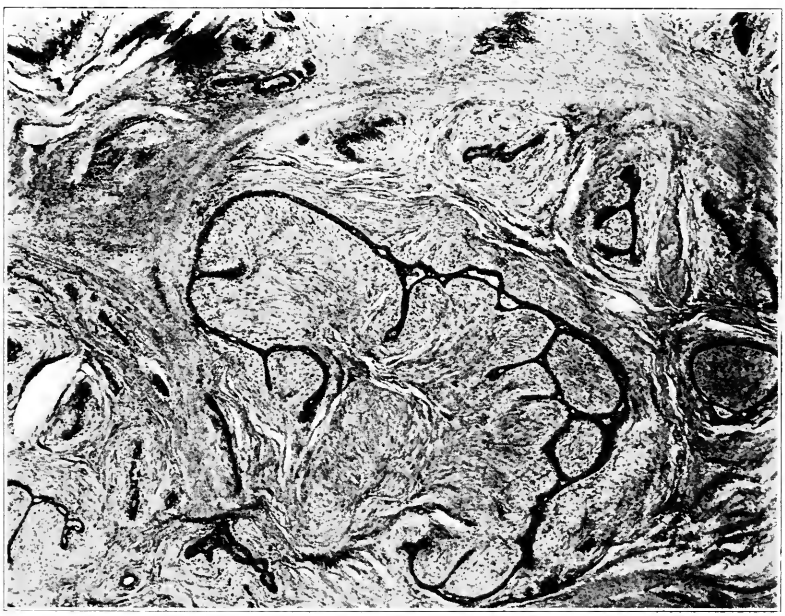


FIG. 118.—Periductal fibroma. Intracanalicular type, showing slit cysts, loose periductal fibrous tissue, and dense interlobular connective tissue. (Greenough and Simmons.)

In only the very rarest instances does carcinoma occur in a periductal fibroma, although there is nothing to prevent the coincidence of the development of carcinoma in a breast already the seat of a fibroma. The causal relation, however, is hard to demonstrate.

Diagnosis.—Single or multiple rounded, nodular tumors in the breast of a young woman, non-adherent, of slow growth and without axillary-gland involvement, are the characteristic features of the periductal fibroma.

Prognosis.—The prognosis is for slow but gradual increase in size. Sarcoma may develop in such a tumor but carcinoma very rarely does so.

Treatment.—The tumor should be removed by the method best adapted to guard the remaining breast tissue from mutilation. Direct incision over the tumor is to be avoided in the upper inner quadrant on account of the disfiguring scar. Many fibromata can be reached and removed by the Thomas incision from the axillary border of the breast. When completely removed the tumor will not recur.

Periductal Myxoma and Sarcoma.[1]—Reference has been made above to the development of edema in the fibrous tissue of a periductal fibroma sufficient to suggest myxoma. Actual myxomatous tissue (similar to that of the umbilical cord) is occasionally found in the larger tumors of the periductal group and must be regarded as a step in the direction of malignant transformation to the sarcoma type. This is an unusual event, but occurs with sufficient frequency to merit consideration in dealing with any rapidly growing tumor of the periductal type, or, indeed, in any tumor of considerable size.

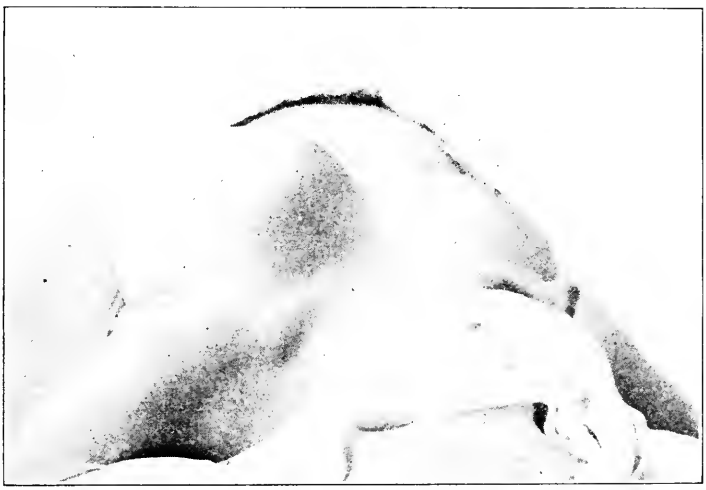


FIG. 119.—Periductal myxosarcoma of breast. (Massachusetts General Hospital.)

Periductal Myxoma or Myxosarcoma (*Cystic Sarcoma, Adenosarcoma* (Williams),[2] *Cystosarcoma Proliferum, Cystosarcoma Phyllodes*) occurs later in life than the fibroma, but, as a rule, before the menopause. In many cases a history can be obtained suggestive of the long existence of a fibroma, of small size, which later took on more rapid growth (Figs. 119 and 120). Such tumors may reach enormous size and the rounded, nodular and bossy outline, the dilated veins, the skin stretched thin to the point of ready excoriation and ulceration and the

[1] Greenough and Simmons: Ann. Surg., October, 1911, p. 517.
[2] Diseases of the Breast, 1894, London, John Bale & Sons.

absence of evidence of glandular involvement in the axilla and above the clavicle form a picture characteristic of sarcoma. Degenerative phenomena are frequent and large cyst cavities may occur, partly due to disintegration of the tissues and partly to the accumulation of blood in the cyst spaces and clefts of the preëxisting gland ducts. When ulceration of the skin occurs the rapid decomposition produces a most offensive discharge.

Periductal myxosarcoma is malignant in the sense of being locally invasive, but it is rarely metastatic to other regions and the lymphatics are not, as a rule, affected. If the tumor is susceptible of local removal a cure may take place, and even repeated local removals have in some cases been successful in eradicating the disease. The ordinary round- or spindle-cell sarcoma occurs rarely in the region of the breast as in other regions of the body. It is to be distinguished clearly from periductal sarcoma and will be described among the "non-indigenous" tumors of the breast.

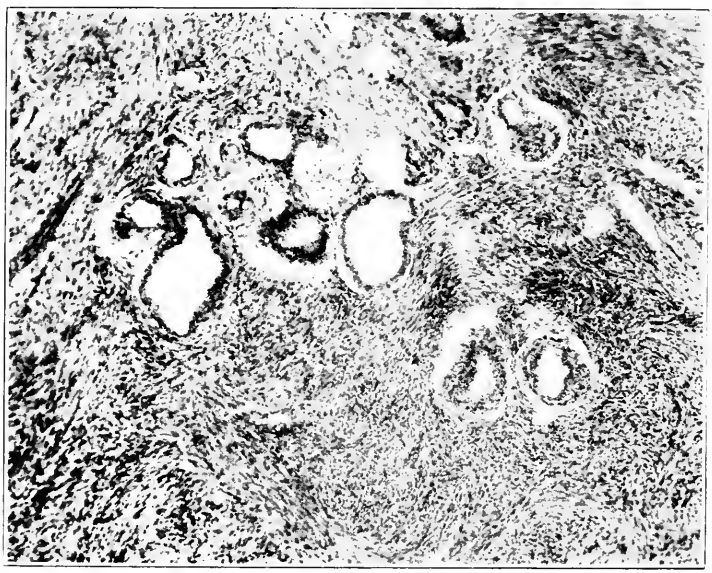


FIG. 120.—Periductal sarcoma of breast. (Massachusetts General Hospital.)

Fibro-epithelial Tumors of the Epithelial Type.

In a certain number of the indigenous fibro-epithelial tumors of the breast the active growth of the epithelial elements of the tumor warrants the description of this group of tumors as a more or less distinct entity, not only from a pathological but especially also from a clinical point of view. Tumors of this type have been described under the names of adenoma, cystadenopapilloma, villous papilloma, duct cancer, intracanalicular papilloma, pure adenoma, etc. It is possible to distinguish two types of these tumors, which will be described under the following terms: Papillary Cystadenoma; Fibrocystadenoma.

Papillary Cystadenoma (*Villous Papilloma, Duct Cancer*).[1]—Papillary cystadenoma is one of the rarer forms of benign tumors of the breast. Williams found 18 cases, or less than 1 per cent., in 2397 breast tumors of all sorts which he examined. The tumor occurs, as a rule, later in life than the fibrous forms of fibro-epithelial tumors, and at the period of full functional activity of the gland. Very rarely cases are encountered in early life, and even in old age.

Papillary cystadenomata are localized tumors, either single or multiple, and occur either in the main ducts of the breast, near the nipple, or develop in the walls of cysts. The characteristic feature of the tumor is a papillary outgrowth from the wall of the cyst (Fig. 121). These papillary growths have a vascular branching connective-tissue stalk supporting a luxuriant growth of epithelium in the form of villous projections and gland-like interlacing tubules and canals (Fig.

FIG. 121.—Papillary cystadenoma. Large cysts with extensive intracystic papillary growth. (C. C. Simmons, Massachusetts General Hospital.)

122). These tumors are primarily well encapsulated and may exist in this benign form for years. In certain instances, however, with advancing years the epithelial growth takes on a malignant character and invasion of the pedicle or wall of the cyst takes place. This change is estimated by various writers to take place in from 15 to 50 per cent. of all cases, and produces, as a general thing, a small-cell adenocarcinoma, which is of a high degree of malignancy and tends to rapid dissemination. The most characteristic symptom of the papillary cystadenoma is the discharge of blood or blood-tinged fluid from the nipple. This symptom occurs in about 50 per cent. of cases and depends upon the patency of the ducts between the cyst and the outside world. In almost every case bloody fluid is found in the cyst, due to the delicate

[1] Bryant: Diseases of the Breast, Cassell & Co., London 1887; Greenough and Simmons: Ann. Surg., February, 1907; Williams: Diseases of the Breast, 1894, London, John Bale & Sons.

villous structure of the papilloma and the ease with which laceration or thrombosis of the bloodvessels may occur. Tumors of this type are

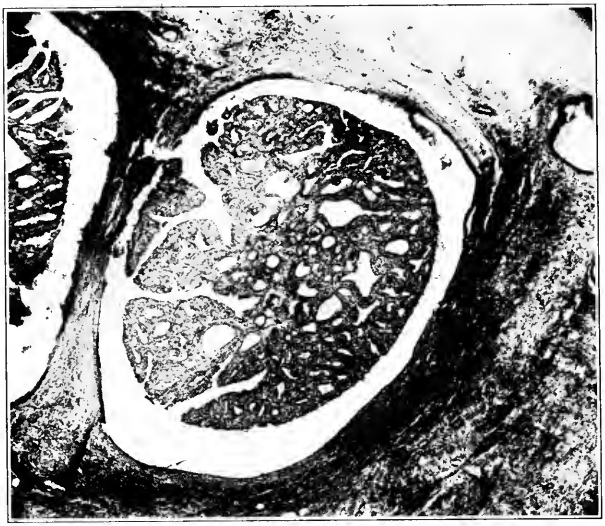


FIG. 122.—Papillary cystadenoma of breast. (Massachusetts General Hospital.)

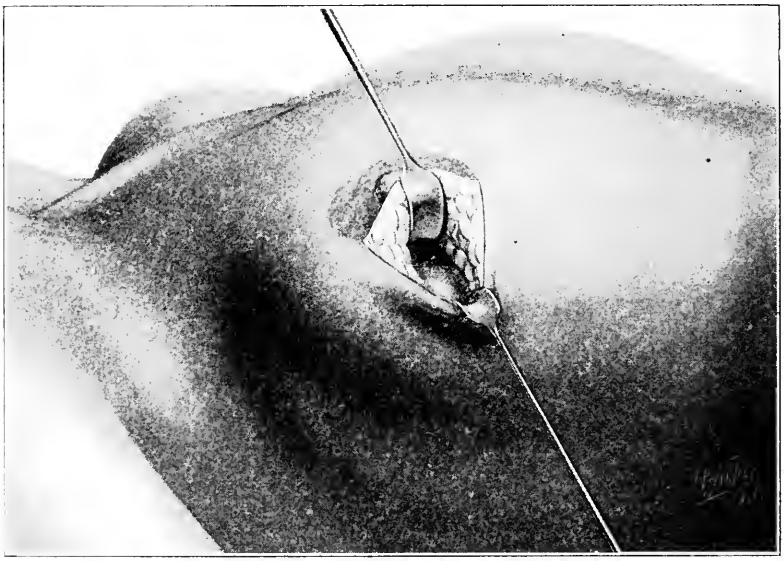


FIG. 123.—Areolar incision for removal of papillary cystadenoma of breast near to the nipple. (R. B. Greenough.)

of slow growth and in a considerable number of cases the bloody discharge from the nipple is the first recognizable symptom; even then the detection of the cyst from which the blood comes may be extremely

difficult or impossible and the bleeding nipple is erroneously attributed to vicarious menstruation or some other rare phenomenon.

Diagnosis.—The diagnosis of tumors of the papillary cystadenoma type depends upon the existence of a painless rounded or cystic tumor, usually near the nipple, but is made almost certain by the presence of the discharge from the nipple of bloody fluid. Unless malignant transformation has taken place the skin is not adherent and the axillary glands are not enlarged.

Treatment.—On account of the danger of malignant metamorphosis of these tumors their radical removal is, of course, to be advised. In older women an amputation of the breast will be the operation of choice, but in young women a less radical removal is justified if it can be accomplished without obliteration of the ducts and destruction of the function of the breast. For such cases the so-called "areolar" incision may be employed—the skin being incised in a semicircle following the outer border of the areola, dissection then being carried down to the tumor in radial strokes to avoid wounding the main ducts of the gland (Fig. 123). Removal of the tumor may be accomplished by this method without interference with subsequent lactation.

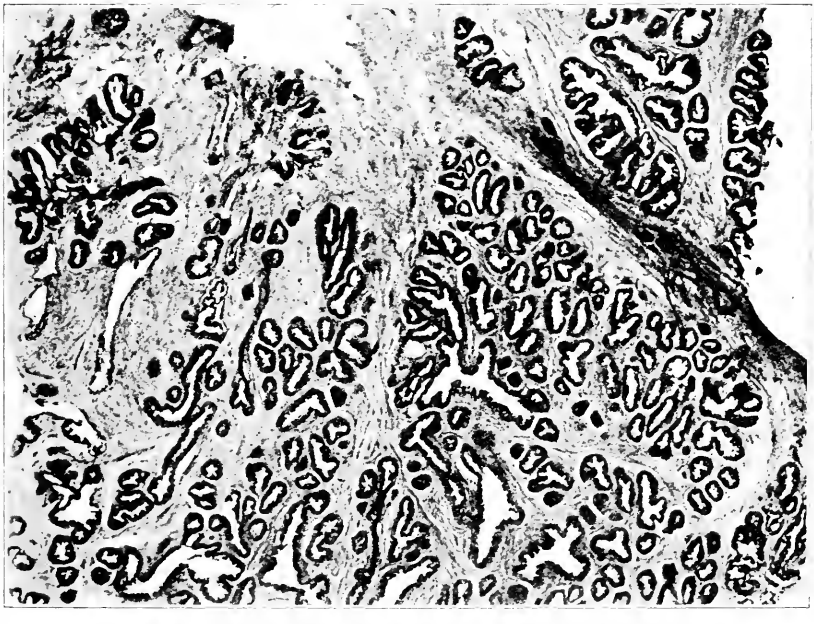


FIG. 124.—Fibrocystadenoma of breast. (Greenough and Simmons.)

Fibrocystadenoma.[1]—A very small group of fibro-epithelial tumors of the epithelial type remain to be described under the title of Fibrocystadenoma. These are tumors of the periductal fibroma class in

[1] Greenough and Simmons: Ann. Surg., October, 1911, p. 517.

which a primary or secondary growth of the epithelial elements has taken place sufficient to alter the preponderance of fibrous tissue, which is characteristic of the fibrous type (Fig. 124).

These tumors occur at the same period of life, or perhaps a little later in life, than periductal fibroma, and they present the clinical characteristics of the fibroma, with the sole exception of slightly more rapid growth. Their diagnosis is established only by the microscopic examination of the tissue removed. They do not seem to show any tendency to sarcomatous change, and in our experience they do not show any special predisposition to carcinoma. The number of cases observed, however, are too few to permit of valuable deductions in this respect. Their treatment is the same as the treatment of the periductal fibroma—namely, excision of the tumor through the incision which gives the least mutilation of the breast.

A very small number of tumors of the breast have been described in which the histological picture of the functional lactating breast is repeated in the tumor. Rodman[1] describes such a tumor under the title of "pure adenoma," and a few other cases are on record. The writer has encountered one case of this character, and it must be admitted that such a tumor exists, although of the greatest rarity. It is possible that tumors of this nature may be associated with aberrant or sequestrated islands of breast-gland tissue, such as are associated with supernumerary breasts. Their diagnosis, however, depends entirely upon histological examination of the tissue.

To sum up the main characteristics of the indigenous fibro-epithelial tumors of the breast, two main types may be recognized—the fibrous type and the epithelial type. The most common example of the fibrous type is the periductal fibroma, the common fibro-adenoma or intracanalicular papillary fibroma of the breast of the young woman. The epithelial type of fibro-epithelial tumor is less common than the fibrous type, and the most common manifestation of this group is the papillary cystadenoma—a tumor of cystic character usually near the nipple and accompanied in many cases by bloody discharge from the nipple. In the epithelial type of tumors the frequency of change to adenocarcinoma is such that radical treatment, at least in older women, is to be advised.

Non-indigenous Tumors.

A certain number of tumors of the breast occur which are in no way characteristic of that organ, but which may be found in the breast as in all other portions of the body, composed, as it is, of connective tissue, nerves, bloodvessels and lymphatics, and covered by the outside skin. These tumors differ very slightly, if at all, when in the breast, from their characteristics in other situations in the body, and they do not require detailed consideration, although they must be mentioned in a chapter on tumors of the breast.

[1] Diseases of the Breast, 1908, Blakiston, Philadelphia.

Lipoma.—Fatty tumors of the breast occur in two forms—diffuse and circumscribed. Diffuse lipoma is part of a general lipomatosis and is not, properly speaking, a real tumor. Fat is very commonly deposited in the region of the breast, especially in older women, when it takes the place of the atrophying glandular elements, and often results in an increase in the actual size of the breast while the functional elements are diminishing or have actually disappeared.

Circumscribed lipomata are rare in this region and occur more in the region of the breast than in the organ itself. Surgical treatment is rarely needed, but the tumor may be excised if considerable deformity is present.

These tumors may acquire a very large size. The editor has encountered one weighing a trifle over five pounds, whose size interfered to a marked extent with the patient's ability to use the left arm, and whose weight was sufficiently great to become an actual burden to the patient. The growth of this tumor had been constant from the time it was first noticed, when the patient was about twenty years old, until the time of its removal, when the patient was thirty-eight.

Enchondroma (*Osteoma*).—Tumors of the breast containing cartilage or bone have been reported as cases of extreme rarity and surgical curiosities. In the sarcomata the production of cartilage and of bone may occur, and tumors of this nature arising in the fascia and bones of the chest wall may come to occupy the region of the mammary gland. Degenerative changes in the fibromata may produce substances closely resembling bone or cartilage, and areas of cartilage have occasionally been noted in the breast as congenital sequestrations from the bony skeleton. The treatment of tumors of this nature depends upon the accompanying conditions, but, as a rule, the indications are for immediate removal by operation.

Angioma.—Tumors composed essentially of bloodvessels of a normal type occur in the breast as in other regions of the body covered by integument, and involve the underlying structures only secondarily. They are the familiar nevi of congenital origin. Increase of development after birth commonly occurs. Their treatment is that of angiomata of other regions—by excision, freezing, radium, or the actual cautery. Other skin tumors, among which should be mentioned keloid, sebaceous cysts and melanosarcoma are found in the breast in very rare instances, as in other regions of the body.

Other benign connective-tissue tumors of the breast occur of such extreme rarity as to deserve mention only for the sake of completeness. Among these are the lymphangiomata, lymphatic cysts, neuromata, leiomyomata and dermoid cysts. The diagnosis of tumors of this nature is established in the majority of instances only after operation.

Sarcoma.—Almost every variety of sarcoma has been reported in the breast, including spindle-, round-, giant-, and mixed-cell sarcomata, fibro-, myxo-, chondro-, osteo-, lympho-, alveolar, angio- and melanotic sarcomata.

All of these forms of sarcoma arise from the interstitial connective

tissues, or from embryonic "rests" of connective-tissue origin. They present in the breast the same variety of cells or cell arrangement which are characteristic of their growth in other regions. Their removal is indicated at the earliest opportunity and the prognosis for continued freedom from recurrence depends entirely upon the malignancy and extent of the new growth in the individual case and on the possibility of its complete removal.

The non-indigenous sarcomata form less than one-half of all sarcomata of the breast and all of the sarcomata together produce only about 1 per cent. of all tumors of the breast.

Carcinoma.—Carcinoma of the breast is one of the most common and most dreaded diseases of women which is known. Every aspect of the disease has been the subject of exhaustive investigation, and its origin is yet a mystery. The term carcinoma is applied to malignant disease of epithelial origin, but the more popular term of cancer is also frequently used in the same connection.

Carcinoma is a malignant new growth which takes origin in the epithelial gland tissue of the breast, and by its atypical growth and extreme proliferative power, infiltrates surrounding tissues and extends to distant portions of the body. Carcinoma tissue is made up of epithelial cells and a fibrous-tissue stroma. The epithelial cells are atypical in form and arrangement, and are massed in columns in varying numbers. The stroma is of dense or delicate fibrous tissue and is formed from the preëxisting connective tissue of the part affected. Round-cell infiltration and chronic inflammatory changes are generally found in the stroma in the more rapidly growing or rapidly degenerating tumors.

The female breast is one of the most common sites of cancer, coming second in women only to the uterus. Cancer also presents an overwhelming majority over other tumors of the breast. (Billroth, 82 to 18 per cent.; Williams, 77 to 23 per cent.)

Etiology.—The etiology of cancer has long been a matter of lively controversy, and from the multitude of theories advanced no one can be accepted as entirely satisfactory. Investigation appears to justify the statement that cancer is assigned as the cause of death in the civilized world more frequently with every decade, but whether this increase is actual or whether it is apparent only, and due to greater accuracy in registration and diagnosis, is yet thought open to discussion. Geographical and social conditions of life, food supply, heredity and trauma have all been urged as factors of etiological importance. A parasitic origin of cancer has been believed by many to be susceptible of proof, although the greater portion of the scientific world maintains an attitude of skepticism upon this point. Certainly, it may be said that the proof of a parasitic cause for cancer has not yet been offered.

Among the theories which have reached the widest acceptance is that of Cohnheim which attributes cancer to embryonic "rests" of tissue, lying dormant until stimulated by some unknown agent and

then proliferating with embryonic activity. Rippert considers the first step of cancer development to be the separation of epithelial cells from their normal situation by the activity of the connective tissues. Baird has attributed cancer to embryonic "rests" of cells of a character similar to the sexual elements of the body and endowed with the sexual characteristics of active proliferation. The fact that the breast and the uterus are the two most common sites of cancer in the female, and that of these organs, more than all others, extreme degrees of post-embryonic proliferation and special function are demanded, gives support to the idea that cancer is due to causes inherent in the activity of the cell rather than to any external or infectious cause. The nature of these causes of cell activity, however, is still a mystery.

Cancer of the breast occurs in all climates and countries, but reaches its greatest proportion of victims in the temperate zones. Low-lying lands have been thought to predispose to cancer more than a high altitude and dry climate. All races are subject to the disease, although the white race provides the greatest number of cases. The age of onset varies within wide limits, but the majority of cases of cancer occur at or about the time of the menopause—at forty-five or fifty years of age. Cases in young women of twenty-one and twenty-two are very rarely reported, but among the very old, seventy to eighty years of age, it is not so infrequent. Married women are more susceptible to cancer than single, and those who have nursed children more than those who have not. The diseases of lactation, acute and chronic mastitis, and the results of interrupted lactation appear to favor the disease.

Heredity has long been considered a factor of importance in the incidence of cancer, and innumerable family histories have been cited in support of this belief. On account of the extreme frequency of the disease, however, a certain number of instances of occurrence of cancer in several members of one family would appear to be inevitable even if the cases were distributed purely by chance. Until recently the influence of heredity has been viewed with skepticism by many writers. The studies which have been made in the past ten years of the transplantable tumors of mice and the inherited tendency to the occurrence of primary tumors in mice have brought this subject again into discussion. The work of Maud Slye, in Chicago, and of Tyzzer and Little[1] in Boston, seem to indicate, without doubt, that the inherited susceptibility to cancer in mice, though a complicated characteristic, is one definitely transmissible from parent to child. At the present writing, however, no more can be said than that the influence of heredity remains still a matter of active discussion and experimentation.

Trauma has been considered of importance by many writers, but the percentage of cases is very small in which a relation between trauma and the onset of the disease is evident. Chronic inflammations and diseases of the breast, and especially other tumors of the breast when

[1] Jour. Med. Research, 1916, xxxiii, 393.

of an epithelial character (papillary cystadenoma), and cystic disease of the breast, seem to give the most probable predisposition to carcinoma.

Classification.- The pathological classification of the different forms of carcinoma of the breast is based upon the microscopic composition of the tissue: (1) Medullary and scirrhus forms of cancer are thus distinguished, according to the proportion of the epithelial carcinoma cells to the connective-tissue stroma. In medullary carcinoma (Fig. 125) the epithelial cells lie in large aggregations, the tissue is soft and succulent, the growth and the degenerative processes are rapid, and the malignancy is extreme. (2) In scirrhus forms (Fig. 126) the epithelial cells lie in slender columns enclosed in a dense and abundant connective-tissue stroma, the tumor is hard and fibrous, the growth is slow, and the

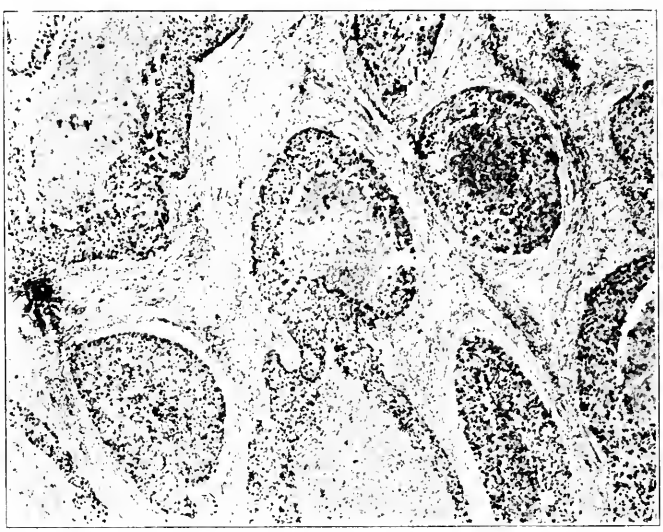


FIG. 125.—Medullary carcinoma of breast with central increase of large masses of carcinoma cells. (R. B. Greenough, Massachusetts General Hospital.)

degree of malignancy is somewhat less than in the more cellular varieties. It must be borne in mind, however, that these distinctions are possible in only a minority of specimens, and that between the two extremes an infinite variety of forms of cancer will be found to which neither the term medullary nor scirrhus can be applied. As a matter of fact, marked variations in cell richness and in the arrangement of the cells are often found in adjacent portions of the same specimen of carcinoma. With the continued growth and dissemination of a carcinoma an increase in cell richness and a gradual approach to the medullary type and to a greater degree of malignancy may occasionally be observed in the more remote metastases.

Attempts to divide breast carcinoma into acinous and tubular forms, according to the origin from the acini or from the ducts of glands, are

not successful. It is rare that this origin can be determined with certainty. The term acinous cancer is best replaced by medullary and the term tubular cancer by a third variety—adenocarcinoma.

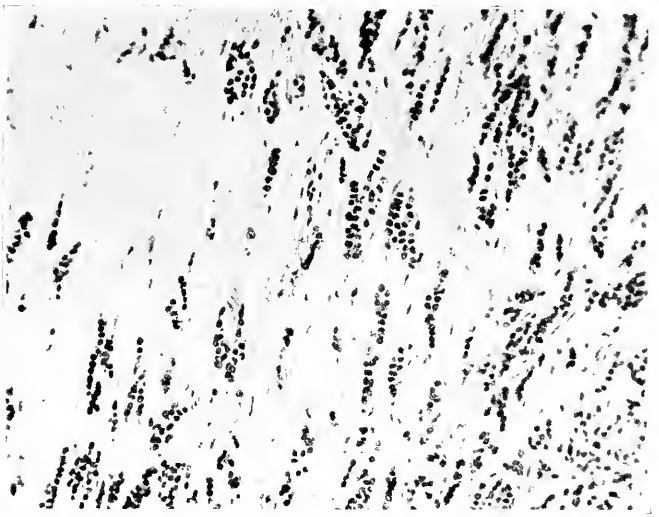


FIG. 126.—Scirrhus type of carcinoma, with cells in single and double column, and dense fibrous tissue stroma. (R. B. Greenough, Massachusetts General Hospital.)

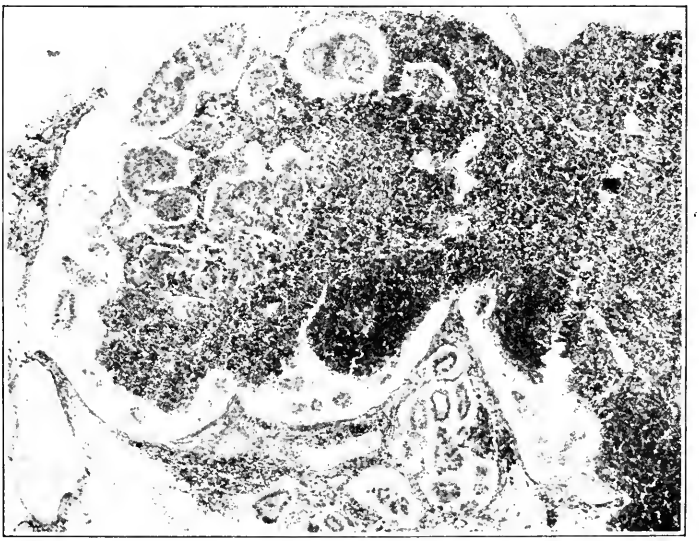


FIG. 127.—Adenocarcinoma. Metastatic in an axillary lymph node. (R. B. Greenough, Massachusetts General Hospital.)

Adenocarcinoma (Fig. 127) signifies a type of cancer in which the departure from the normal type of gland tissue is at a minimum and

the degree of malignancy, as a rule, correspondingly low. It probably arises either from the ducts or from the acini. The collections of epithelial cells retain their tendency to form themselves about an open space—the lumen of the gland. The growth of epithelial cells is, as a rule, less rapid than in other forms and departure from the normal type ("Anaplasia"—Hansemann[1]) is less extreme. Metastasis does not occur so rapidly as in other forms of cancer, but continued growth allows increase of malignancy and progress toward the medullary type of the disease. Adenocarcinoma is the form which is especially liable to supervene upon neglected cases of cystic disease of the breast. The volume attained by a tumor of the adenocarcinoma type is often greater than is produced by medullary cancer of the same duration,

FIG. 128.—Colloid carcinoma of breast. (R. B. Greenough, Massachusetts General Hospital.)

but metastatic growth is generally less rapid and the tumor is thus less malignant. A small-cell type of adenocarcinoma ("adenocarcinoma destruens") of a higher degree of malignancy than that described above is sometimes seen to develop in cases of papillary cystadenoma, and to spread with great rapidity.

Another form of cancer of the breast is colloid carcinoma (Fig. 128) which derives its name from a peculiar mucinous degeneration which produces masses of gelatinous substance in the older portions of the tumor. The cause of this degeneration is unknown. It may affect either epithelial or connective-tissue elements, and in some cases both tissues undergo a mucinous degeneration. Colloid cancer is rare and is

[1] Die Mikroscopische Diagnose der Bösartigen Geschwülste, 1897, Berlin, H. Hirschwald.

generally one of the less malignant forms of the disease. Its spread is very slow, and it sometimes remains definitely encapsulated, even at the point of origin, for many years.

An unusual form of cancer of the breast is "cancer of the axillary border" (Warren[1]), due to the occurrence of cancer in an outlying lobule of the breast or in a supernumerary mamma. Epidermoid cancer of the skin of the breast and its relation to chronic eczema and "Paget's disease" has been discussed under Diseases of the Nipple. Epidermoid cancer of other origin is of extreme rarity in the integument of the mammary gland.

Cancer Cysts.—A very rare form of carcinoma, which has been studied especially by Bloodgood,[2] is the so-called cancer cyst (Fig. 129), a smooth-walled cyst containing bloody fluid, the wall of which is made up of cancer tissue. It is not certain exactly how these tumors originate, but it is probable that the carcinoma surrounds a preëxisting cyst and

FIG. 129.—Cancer cyst of the breast. Smooth-walled cyst with bloody contents and no intracystic papillary growth. (S. J. Mixter.)

infiltrates its wall. The distinguishing characteristic of this form of carcinoma is the extreme malignancy which it possesses and the rather indefinite symptoms. In its early stages it is mistaken, in diagnosis especially, for cystic disease of the breast or chronic abscess. Its treatment is that of other forms of cancer of the breast, and the most radical operation possible is indicated, although the prognosis is definitely unfavorable.

Cancer occurring in a breast which is in lactation has also been dignified by a special term, "Cancerous Mastitis." The increased vascularity of the gland and its more abundant lymphatic circulation at the time of lactation are especially favorable to the rapid growth and spread of the infiltrating new growth. "Cancerous Mastitis" is thus of extreme malignancy, and a rapidly fatal termination can rarely be avoided.

[1] Jour. Am. Med. Assn., 1905, xiv, 160; also International Text-book of Surgery, 1900, vol. ii, chapter viii.

[2] Am. Jour. Med. Sc., February, 1908.

The degenerative changes in the tissues of cancer of the breast are of great variety. The older and more central portions of the epithelial columns first become deprived of nourishment, and undergo anemic necrosis and fatty degeneration. Interference with the blood supply may cause necrosis of whole portions of the tumor, and all varieties of degenerative processes are thus produced. Hemorrhagic areas are not infrequent, and infection by microörganisms may occur, with sloughing and suppuration, by extension through the overlying integument. Tumors showing extensive cavities filled with fluid necrotic material have occasionally been described as "cystic carcinoma." Small areas of necrosis occasionally undergo inspissation, and in slow-growing carcinomata the deposit of lime salts in such areas has been recorded.

Growth.—The main characteristic of cancer of the breast, like that of other organs, is the faculty of progressive infiltrating growth, and of extension by metastases, to other parts. Invasion of tissues by direct continuity produces extension of the tumor to the skin above, and to the muscles, fasciæ, ribs, sternum and pleural cavity below. In this manner the tumor mass becomes more and more firmly fixed in its position. Extension to other regions is produced especially by way of the lymphatics, although penetration of the wall of a vein, and metastasis by the blood current, may rarely occur in the late stages of the disease. The lymphatics have long been recognized as the chief carriers of cancer growth. For this reason the anatomy of the lymphatics of the breast has received special consideration, as outlined in the section on Anatomy of the Breast. Cells or groups of cells appear to make their way into the lymphatic vessels and to grow along them (permeation—Handley[1]) or be carried to the nearest lymph nodes, where they find conditions suitable for growth, and produce a tumor similar to that from which they were derived. Blocking of one set of lymphatic channels by metastatic growth may produce new channels of compensatory circulation, until these are again blocked by further metastases. In this way cases of apparent retrograde lymphatic metastasis are produced. Extension from a node once infected to that nearest above it may continue until the free circulation in the thoracic duct is reached, and general metastasis or carcinomatosis is produced.

The susceptibility of the different organs and tissues of the body to carcinomatous metastasis appears to be subject to variation. Among the tissues in which this susceptibility is most conspicuous may be mentioned the lungs and pleura, the liver, the bony skeleton, and the brain. The bones most frequently involved are the sternum and ribs, the humerus, femur, and spinal column.

Symptoms.—The symptoms of carcinoma of the breast are insidious. A woman of middle age notices a hard mass in the substance of the breast. Attention is generally called to the tumor by accident, and pain is rarely felt, although a certain amount of tenderness may be present. Often the tumor has been noticed for a long time, and dread

[1] Surg., Gynec. and Obst., 1915, xx, 72.

of a certain diagnosis and a probable operation, influences the woman to delay in seeking medical advice.

Upon examination a hard mass is felt in the breast, most commonly in the upper outer quadrant. The nodule may be minute, or the whole breast may be involved and a projecting tumor mass may be presented. (Fig. 130). The outline of the tumor is well defined, and the mass can be rolled under the finger when the breast is flattened against the chest wall. The skin of the breast is generally more closely adherent at the site of the tumor than elsewhere, by the involvement and infiltration of the fascial fibers which extend from the gland stroma to the integument (ligaments of Sir Astley Cooper). The nipple is often retracted by the growth between the ducts, especially in the large or more centrally disposed tumors (Fig. 131). Discharge from the nipple is rare. The more fibrous forms of cancer of the scirrhus type differ from the

FIG. 130.—Carcinoma of breast of adenocarcinoma type, with projecting tumor.

foregoing in that extreme retraction of the skin or of the nipple may occur, with marked diminution of the natural prominence of the breast, while yet the tumor is so small as to escape notice without careful examination. The more extensive tumors soon become adherent to the skin, and dilated veins are evident as the skin is thinned above the tumor. In such cases trauma and infection frequently start a sloughing, suppurative process which results in an irregular, ulcerated surface, with offensive discharge. Cancerous cachexia soon makes its appearance. This is a form of secondary anemia which is due to the absorption of the products of tumor growth and of cell degeneration. The skin presents a peculiar unhealthy pallor, and a yellowish tint is not uncommon. General constitutional symptoms, such as weakness, loss of weight, fatigue, and digestive disturbances accompany the condition. The blood is deficient in red cells and in hemoglobin, and a moderate

leukocytosis is often found. The extension of carcinoma to the skin in small areas (lenticular nodules) may occur, or a diffuse subcutaneous lymphatic involvement may lead to a widespread leathery induration

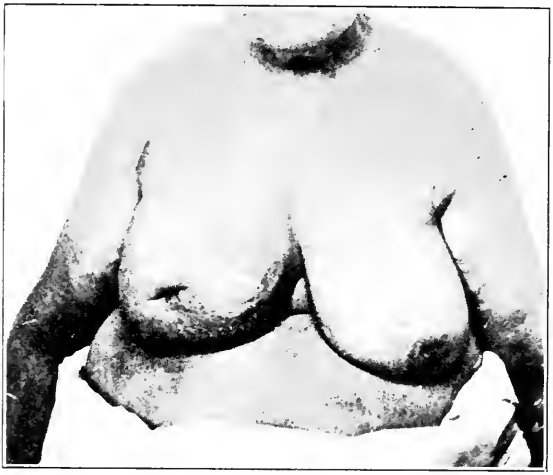


FIG. 131.—Carcinoma of the breast of scirrhus type, with retraction of nipple. (Massachusetts General Hospital.)

FIG. 132.—Cancer en cuirasse. Recurrence after operation.

(peau d'orange), or to an encircling girdle of cancerous tissue (cancer en cuirasse) (Fig. 132). Rarely a brilliant scarlet discoloration of the skin appears, accompanied by a considerable infiltration, and sug-

gesting strongly the appearance of erysipelas, but without temperature or constitutional symptoms, and of a chronic course, fading gradually to a bronze color and the indurated condition above described as "peau d'orange." Fixation of the breast upon the chest wall occurs by the direct involvement of the fasciæ and muscles of the chest wall and even of the ribs. Extension of the growth along the main lymphatic trunks under the border of the pectoralis major, toward the axilla, is early. Metastasis occurs first, as a rule, in the anterior axillary lymphatic glands. The exceptions to this rule are the rare cases in which the process begins in the median portions of the breast. In these cases extension to the glands of the anterior mediastinum, or to those above the clavicle, may first occur. The axillary glands are generally already involved by the time the primary tumor has itself become large enough to attract attention. One or many glands in the axilla may be diseased, and the pressure they exert on the axillary vein, together with the obstruction of the lymphatics, may cause a hard edema of the hand and arm of the affected side—the "brawny arm of breast cancer"—which is an indication of extension of the disease beyond the limits of relief by operation. From the axillary glands extension to the subclavicular and supraclavicular glands is rapid.

The course of cancer of the breast, when not relieved by operation, is progressive, and a fatal termination is accepted as a merciful relief. The primary tumor often becomes an offensive, ulcerated mass. Direct extension of the disease involves one after another of the tissues of the chest wall until the pleura is reached, and a hemorrhagic effusion compresses the lung. Extension by the lymphatics, and invasion of the blood stream causes metastatic growths in distant organs, with the accompanying symptoms to which the local tumor growth gives rise. Death may occur early, by lung involvement and pneumonia. Metastases in the long bones, producing "spontaneous" fracture, or in the vertebral column with compression of the cord, paralysis, and bedsores, may cause sufferings which are terminated only by a lingering death from exhaustion.

It was hoped that the *x*-ray would serve to establish the presence of carcinomatous metastases in the bones, but it has been found that the early and smaller nodules are too small to be shown by the *x*-ray, and rarely can the extension of the disease be discovered in this way before the clinical symptoms of pain and swelling have made the diagnosis already probable.

Diagnosis.—The diagnosis of cancer of the breast is somewhat facilitated by the frequency of the disease which makes possible the general rule that a tumor of the breast in a woman past middle age may be considered to be cancer until evidence to the contrary is produced. The pathognomonic signs of carcinoma are found in the more advanced and inoperable cases—a hard tumor infiltrating the breast and fixing it upon the chest wall, with puckering of the overlying skin, enlarged axillary glands, and beginning cachexia. In early and operable cases the diagnosis is more difficult, and practically all diseases of the breast

must be considered. Acute inflammatory conditions are recognized by their pain and tenderness, and by acute onset and rapid development. Absence of pain in a tumor is always suggestive of cancer. The chronic inflammatory conditions of the breast—gumma, tuberculosis, and chronic abscess of the breast—are to be recognized by their characteristic histories, and by the absence of skin involvement and of axillary and remote metastases. Tuberculosis, as a rule, causes enlargement of the axillary glands, but the evidence of tuberculosis elsewhere, and the tendency to suppuration and sinus formation, are generally sufficient indications. Chronic abscess of the breast may be indistinguishable from cancer until after removal of the tumor.

Cystic disease of the breast presents probably the most confusion in the diagnosis of cancer of the breast. The elastic feeling of small tense cysts, and the actual fluctuation of larger ones cannot always be elicited. Discharge from the nipple favors cystic disease, or cystadenoma. The ill-defined outline of the induration, the absence of axillary involvement, and the lack of extension to skin or muscle in cystic disease, aid in the diagnosis. Puncture with the exploring needle may establish with certainty the presence of cysts which have been suspected, but is of absolutely no value in excluding the presence of carcinoma, and is to be condemned. An area of carcinoma may be present in the midst of a cystic breast, and its recognition under these circumstances may be impossible. For this reason alone, exploratory operation is the only safe measure in doubtful cases.

From periductal fibroma, cancer can be distinguished by the following characteristics: periductal fibroma is a disease of young women, and presents a clearly defined, movable tumor, which shows no tendency to involvement of other structures. Papillary cystadenoma of the breast is to be distinguished by its cystic character, and by the lack of evidence of malignancy in the involvement of other tissues. The diagnosis of papillary cystadenoma is aided by the occurrence of a bloody discharge from the nipple.

Sarcoma of the breast is distinguished from cancer by its large size, nodular outline, irregular consistency, rapid degenerative changes, and consequent pyrexia, and by its tendency to avoid lymphatic extension to the axilla, and to produce metastasis by the bloodvessels, if at all, only late in the disease.

Prognosis.—The prognosis of a case of cancer of the breast without operation varies with the form of cancer. Cases of scirrhus or colloid have been known to drag along for twenty years and more, while medullary forms of the disease may cause death within six months. The average duration of life is estimated from one and one-half years to three years. Without operation, the disease progresses to a fatal termination unless death from intercurrent disease or accident intervenes. With operation, statistics vary. The success of operation depends upon the duration and extent of the disease, and especially upon the type of cancer and the completeness of the operation. Statistics vary from 20 to 50 per cent. of cures, and even higher percentages

are obtained in selected cases.[1] The prognosis for duration of life of cases in which recurrence follows operation is said to be slightly better than in cases in which no operation is done. The length of life is somewhat prolonged, and life is made more comfortable by the avoidance or diminution of sloughing and ulceration. Recurrence may occur at long periods after operation, but in the majority of cases recurrence sets in within the lapse of three years if it occurs at all. Three years without recurrence has long been considered the time of probation and at

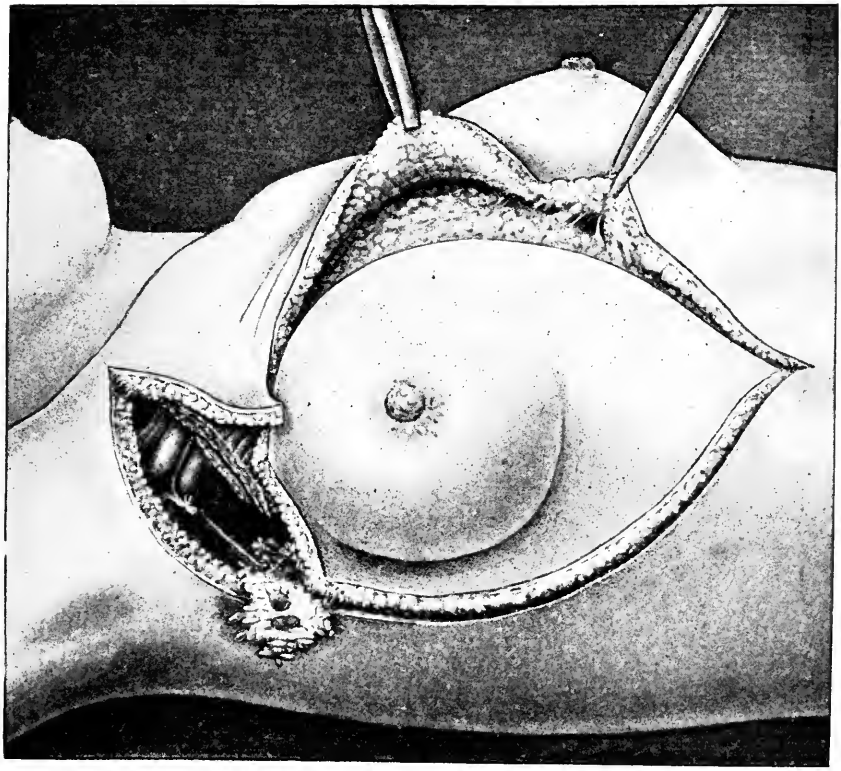


FIG. 133.—Skin incision for amputation of the breast by the transverse axillary incision of Rodman.

the safe termination of this period continued freedom from recurrence may be expected. The exceptions to this rule, however, are well-established, and an element of uncertainty must enter into every reported "cure" of cancer of the breast. The treatment of cancer of the breast by other methods than operation, such as *x*-rays or radium, offers little promise at the present time beyond the relief of pain, and the retardation of the fatal result. Cases of extensive ulceration are frequently

[1] Greenough, Simmons and Barney: Surg., Gynec. and Obst., 1907, v, 39–50; Halsted, W. S.: Tr. Am. Surg. Assn., 1907, xxv, 61.

benefited by these methods of treatment, and in many cases the progress of the disease has been retarded, if not arrested. Further than this the success of the *x*-ray or radium has not been satisfactorily established.

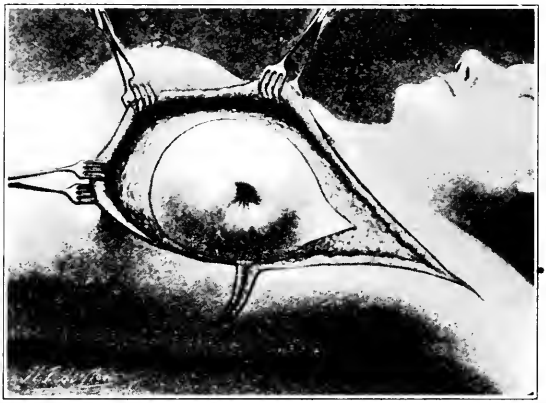


FIG. 134.—Skin incision for radical operation for cancer of the breast. (J. C. Warren.)

Treatment.—The treatment of cancer of the breast is by operation. Absolute and entire removal of all of the disease "en bloc," with a wide

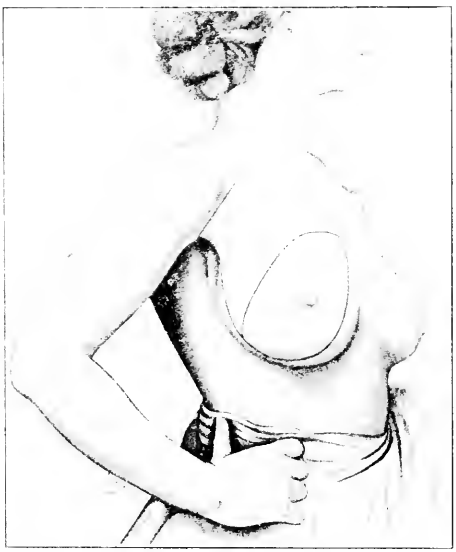


FIG. 135.—Skin incision for amputation of breast, leaving an axillary flap. (Jabez N. Jackson.)

margin of healthy tissue, is the object to be attained. A number of different incisions have been devised for the accomplishment of this

result, beginning with Halsted's[1] curving incision in front of the axilla, a method of operating which is still widely used. Many surgeons, however, prefer the so-called "transverse axillary incision," the type of which is Rodman's operation.[2] (Fig. 133). Whatever method is used one consideration must remain supreme, namely, that all tumor-bearing tissue be given a wide margin, and that the tissues be removed "*en bloc*." This demands the removal of the pectoralis major and minor, and the dissection of the axilla, as well as the amputation of the whole breast and the deep fascia of the chest wall. When this is done there will be many cases in which a sufficient amount of skin to close the wound entirely will not be present, and resort must be had to the use of plastic flaps, or skin graft, to close the defect. A number of different methods of obtaining flaps to close the defect have been

FIG. 136.—Scar left after radical operation; closed by flap and Thiersch graft. (Method of J. C. Warren, Massachusetts General Hospital.)

suggested, no one of which is universally applicable but each of which may be effective in certain cases (Figs. 134 and 135). Where the defect is very large, however, the closure by Thiersch graft, either at the first operation, or at the end of two to three weeks as a secondary operation, is usually employed (Fig. 136).

A description of the standard operation by the transverse axillary incision is as follows:

The field of operation is shaved and scrubbed with soap and water, and put up with a sterile dressing the night before. The field covers a

[1] Halsted, W. S.: Ann. Surg., November, 1894; Jour. Am. Med. Assn., February 8, 1913.

[2] Rodman: Diseases of the Breast, 1908, Phila. Warren: Jour. Am. Med. Assn., 1905, xiv, 160, also Inter. Text-book of Surg., 1900, ii, chapter viii. Meyer: Jour. Am. Med. Assn., July 29, 1905. Jackson, J. N.: Jour. Am. Med. Assn., March 3, 1906, and 1910, liv, 178–183. Stewart, F. T.: Ann. Surg., 1915, lxii, 250.

wide area, and should extend from the line of the jaw to the umbilicus, and cover the entire front of the chest and to the middle line in the back. The axilla is shaved, and the arm is included in the field of operation down to the elbow. When the patient is under the anesthetic half strength ($3\frac{1}{4}$ per cent.) iodin is painted on the skin, and the arm is wrapped in a sterile towel and held by a nurse or bound to an upright on the operating table. The incision is started from just above the middle of the clavicle, and extends downward and backward across the axilla at a point about two inches beyond the axillary prolongation of the breast gland, until it reaches the line of the latissimus dorsi at about the level of the lower end of the scapula. This incision is deepened by bevelling toward the arm in such a way as to leave the fat and fascia, raising only the skin until the front of the shoulder and the axillary fat are exposed. The flap is elevated for about three inches at its greatest depth. With this flap retracted the pectoralis major is

FIG. 137.—Skin incision for amputation of the breast by the transverse axillary incision, modified from Rodman—the "arrow-head" incision. (R. B. Greenough.)

divided as near to its humeral insertion as possible, leaving only the fibers attached to the outer half of the clavicle. The muscle is then retracted toward the breast, and the brachial vein identified at the lower portion of the axilla. The dissection of the axilla is now begun at this point with gauze and scissors, removing the entire contents of the axilla with the exception of the axillary vein and artery, and the brachial plexus. The axillary contents are swept downward and inward toward the breast, and held with fresh pieces of gauze so that the mass of tissue is constantly covered. As the dissection is carried upward to the pectoralis minor this muscle is also divided and retracted toward the breast. The axillary dissection is then completed to the clavicle, special attention being given to the subclavicular glands lying in the space immediately anterior to the axillary vein. The long thoracic nerve (or respiratory nerve of Bell) can usually be left undamaged as it lies against the chest wall. Its preservation should be attempted. The empty axilla is now filled with gauze wet with salt

solution, and the first stage of the operation is accomplished. Incisions are now carried around the breast, meeting in a V in the epigastrium, and extending downward across the middle line to the opposite rectus muscle. These elliptical incisions come out on the axillary incision at a point varying from two to four inches apart, according to the size of the breast, care being taken to remove the skin immediately over the anterior curved border of the pectoralis major (Fig. 137). These incisions are again bevelled outward, the anterior flap of skin being raised to a point beyond the sternum and the posterior flap to the border of the latissimus dorsi and the middle of the serratus magnus. Retraction of these flaps exposes the fat and fascia of the chest wall from a point beyond the sternum to, and slightly beyond, the posterior axillary line, and from the clavicle to a point nearly down to the umbilicus. The mass of axillary contents and pectoral muscles is then swept in a direction toward the epigastrium, and dissected free from the chest wall. The costal attachment of the pectoralis minor is severed, and the clavicular and costal attachments of the pectoralis major are divided close to the chest wall, care being taken to clamp with artery forceps the protruding branches of the internal mammary artery before they are cut.[1]

The investigations of Handley have not been entirely confirmed by other observers, but sufficient evidence exists to justify the removal of the fascia of the upper portion of the two rectus muscles in the epigastrium, and of the fat and fascia between them as a last step in the severance of the breast tissues from the chest wall, and this is becoming a part of the standard operation. The mass of tissue is then removed, including the fat and the deep fascia, to the limits of the exposed area (Fig. 138). Hemostasis is accomplished by catgut ligatures, and a large number of vessels must be tied.

The most important consideration in the entire operation is that no tumor tissue be cut across and spilled in the wound. If this accident does occur the cautery should be used at once upon the affected surface, and the contaminated instruments put aside. It is probable that the vast majority of local recurrences after operation are due to artificial transplantation of the tumor at the time of operation.

The wound left after such an operation as has been described is of great extent, and in many cases the elasticity of the skin is not sufficient to permit the edges to be approximated (Fig. 139). In such cases one or

[1] Editorial Note.—The cicatricial tissue which forms in the axilla after the complete removal of all of the fat frequently causes so much pressure upon the axillary veins that the return circulation is very markedly interfered with. This can be avoided to a great extent by employing a step which was introduced by N. M. Percy. The costal end of the pectoralis minor muscle is dissected from the chest wall, while the distal attachment of this muscle is not interfered with. The fascia of the muscle is removed with the axillary tissues. The distal portion of the pectoralis minor to a length of 6 or 7 cm. is left in position, while the remaining portion of this muscle is cut away. The portion remaining attached is then sutured by means of a few fine catgut sutures to the intercostal muscles in a line to cover the axillary veins perfectly for a distance of 5 to 7 cm., according to the width of the muscle. In this way the amount of connective tissue is greatly reduced and with it the interference with the return circulation.

another expedient must be employed. The wound may be left open to granulate, and Thiersch grafts may be used to close the defect at some

FIG. 138.—Breast and accessory tissues removed in radical operation with the transverse "arrow-head" incision. (R. B. Greenough, Massachusetts General Hospital.)

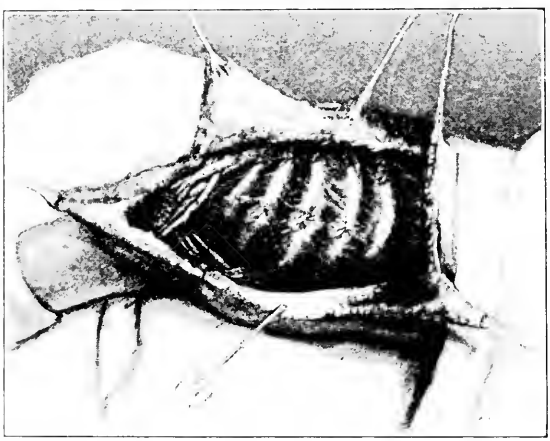


FIG. 139.—Skin flaps raised, showing extent of removal of deep fascia. (R. B. Greenough.)

later date. The disadvantage of this method is the delay in convalescence, but the result after a Thiersch graft, done two or three

weeks after operation, is less unsightly than when the grafts are laid at once upon the denuded surface. Flaps may be raised from the

FIG. 140.—Scar of complete operation, closed by Warren flap. (R. B. Greenough, Massachusetts General Hospital.)

abdomen or from the back, and aid materially in closing the defect (Fig. 140). The opposite breast may also be dissected free from the

FIG. 141.—Cancer of the breast. Sutured wound after amputation of the breast with transplantation of the other breast—the "cyclops" plastic. (S. J. Mixter, Massachusetts General Hospital.)

chest wall and drawn toward the middle line—the so-called "Cyclops" plastic (Fig. 141). No one of these methods is universally applicable,

but the one best suited to the individual case must be employed. One consideration, however, in regard to closure of the wound is of great importance—to avoid a contracting scar, which will limit abduction of the arm, the wound should be closed with the arm in the abducted position. When this is done it is unnecessary to maintain the uncomfortable abducted position of the arm during convalescence, as has been advocated by certain surgeons. The arm should not, however, be included within the dressing but should be held by a wrist sling for the first two or three days, and should then be given gentle passive motion in abduction and rotation during the rest of the convalescence. The return of function in the arm, when both pectorals have been divided, is prompt and almost complete if the contracting scar binding the arm to the chest is avoided. In successful cases the appearance after healing is as if the anterior axillary fold had moved upward to the clavicle on the affected side. If the respiratory nerve is cut, a paralysis of the serratus, and a degree of "angel wing" paralysis is inevitable.

Supraclavicular Dissection.—Where the so-called complete operation is done recurrence, or rather extension, of the disease in the supraclavicular glands occurs with sufficient frequency to merit consideration of the supraclavicular dissection as a part of every radical operation. It is the general consensus of surgical opinion that when enlarged lymph glands, already infected with cancer, can be felt above the clavicle an attempt at radical cure of the disease is futile, and this in spite of the fact that a very small number of cases are recorded of perfect cures under these conditions. In early cases the routine supraclavicular dissection is still under debate, but it does not seem unreasonable when the condition of the glands in the upper portion of the axilla is such as to indicate probable microscopic disease already present in the supraclavicular glands beyond.[1]

The supraclavicular glands should also be removed in every case of cancer in the upper inner quadrant of the breast, because of the occasional direct lymphatic drainage above the clavicle from this portion of the breast. When the transverse axillary incision is used the upper end of the incision can be carried above the clavicle, and the flaps bevelled and elevated as for the axillary operation. The contents of the supraclavicular triangle can then be removed in the same way in which the axillary dissection was carried out. It is unfortunate that this part of the operation cannot be performed "en bloc" with the other tissues removed unless the clavicle is divided, a procedure which adds greatly to the disability of the patient and to the magnitude of the operation, and is usually condemned.

Drainage.—The success of the axillary dissection depends upon the complete removal of the axillary lymphatics. For this reason a considerable discharge of lymph from the arm and chest wall takes place in the axillary space. Unless this is allowed to escape by drains the dead

[1] Pilcher: Year-book of the Pilcher Hospital, Brooklyn, New York, 1912.

space becomes distended, and troublesome collections of serum take place, which invite secondary infection. It is customary to leave a rubber tissue drain in the axilla for from three to four days after operation.

The mortality of the complete or radical operation for cancer of the breast is that of accident, and varies from $\frac{1}{2}$ to 2 per cent. of cases in different clinics. Death may result from pneumonia, or respiratory disease coincident with anesthesia and operation. A certain but very small percentage of cases die of pulmonary embolism, presumably from thrombi in the axillary vein. Very rarely a case of fulminating sepsis occurs, the only instance of this sort in the writer's knowledge being traceable to an ulcerated and infected tumor.

Exploratory Operations.—The statement has been often repeated that the clinical and pathognomonic symptoms of cancer of the breast—retraction of the nipple, fixation of the breast on the chest wall, enlargement of the axillary glands, and cachexia—are in reality the symptoms of cancer of the breast which has extended beyond the possibility of operation for radical cure. If surgery is to increase materially the number of successful cases of operative treatment of this disease, operation must be performed in the early stages, and before positive symptoms have appeared. In other words: operation must be done on the suspicion instead of on the certainty of the presence of carcinoma. It has been agreed by many authorities that the exploratory incision for the removal of tissue for pathological examination is a justifiable procedure in many forms of suspected cancer. In cancer of the breast, however, the exploratory incision, with removal of tissue for subsequent examination, is fraught with such danger of a spread of the disease that it has been definitely abandoned. From 90 to 100 per cent. of cases in which an exploratory removal of tissue has been done and the wound allowed to close, to be followed at a later period, on the receipt of a positive pathological report, by a radical operation, are unsuccessful, and the object of the operation is not obtained. Under these circumstances, the handling of uncertain cases of cancer of the breast is one of considerable difficulty. Any one of several alternatives may be adopted by the surgeon in charge: (1) He may treat every case of suspected cancer of the breast as if it were cancer of the breast and do a radical operation. In this case he will give every patient the best chance for a radical cure at the expense of doing the radical operation unnecessarily in a small number of cases. In the long run, this is probably the safest practice for the surgeon who has not large experience and the resources of the modern hospital at his command. (2) In a small number of cases where the diagnosis is probably benign, but where the existence of cancer cannot be actually ruled out, removal of the breast with the pectoral fascia, but without the dissection of the axilla, can be performed. The breast can then be sectioned and examined by the pathologist, and if cancer is found the additional steps of the radical operation can be performed. The argument for this procedure is that the case, if presenting the symptoms only of a benign

tumor, is not likely to be such an advanced case of carcinoma as to have extended already beyond the limits of the gland itself, and the amputation of the breast is likely to have removed the whole of the diseased area. This is a method of procedure which will be restricted to surgeons who have had considerable experience in diagnosis of diseases of the breast and involves some risk to the patient's chances in any case. (3) Exploratory incision followed at the same sitting by the necessary operation: This method is practiced in many clinics by surgeons who have had long training in gross pathology, and apparently with very little danger to the individual patient. Incision is carried down directly into the tumor, and its cut surface is inspected. If necessary, fragments for frozen sections can be excised. The wound is then cauterized, or packed with formalin gauze, and the operation indicated by the pathological condition is immediately performed. This method, also, will of necessity be restricted to surgeons who have thoroughly trained themselves in gross and microscopic pathology. (4) An expedient is offered by the electrocautery by which nodules of suspicious character can safely be excised without danger of dissemination. The writer has made use of this method in a number of cases, and it is very satisfactory. The cautery is used to incise or excise the suspicious tissue, and an immediate diagnosis is obtained if necessary by frozen section. If it prove malignant, the radical operation is done at once. If non-malignant, the cauterized tissues can be excised with the knife and the wound closed with expectation of healing by first intention. Of the four methods suggested for dealing with doubtful but suspicious cases of cancer of the breast, the cautery exploratory is, in the opinion of the writer, the safest and most satisfactory for general use.

Palliative Operation.—Palliative operations in cancer of the breast are occasionally indicated in patients where no hope of a radical cure can be entertained. In certain cases the so-called radical operation can be done in apparently hopeless cases in order that the patient may be given every possible chance. Such a procedure affects unfavorably the statistics of the individual operator, but very rarely an unexpectedly successful result may be obtained. As a rule, the only cases requiring a definitely palliative operation are those in which a large ulcerating tumor gives so much discomfort to the patient and her attendants that its removal is indicated as a purely temporary relief. In such cases the operation performed with the cautery has many advantages, and the affected mass of tumor tissue can be removed by this method without producing a rapid spread of the disease, which would be likely to follow the opening up of fresh spaces to infection if the operation were done with the knife. The combination of the cautery operation and subsequent *x*-ray treatment has yielded most satisfactory results as a palliative measure in many advanced cases. Under palliative operation may be mentioned the rare but occasional case in which an amputation of the upper extremity is indicated, either for gangrene or for the pain and disability of the "brawny arm," due to axillary

obstruction of the veins and lymphaties, and pressure on the brachial plexus.

Recurrence after operation takes place in from 50 to 70, and even 80 per cent. of cases. Recurrences can ordinarily be distinguished as of three different classes: Local, regional and remote.

Local recurrences take place in the scar, or at least within the boundaries of the area exposed at the primary operation. They are due either to an incomplete removal of the diseased tissue or to artificial operative implantation at the time of the operation, produced by accidental or unavoidable incision into tumor tissue in the wound. A large proportion of recurrences are of this character, and they usually make their appearance within the three-year period, and even in the first year after operation, although instances of local recurrence are recorded many years after the primary operation. With improved technic and wider operations, the proportion of local recurrences has been somewhat diminished.

Regional recurrence takes place in the lymph nodes adjacent to, but beyond the area of the primary operation. Recurrences of this character must be atttributed to infection of the lymph nodes prior to or at the time of the operation, but of such microscopic size that no enlargement of the lymph nodes could be detected. Recurrenees of this nature are not at all uncommon in the supraclavicular glands after radical operations in which the upper axilla is badly involved. The experiments of Tyzzer on mouse tumors have established beyond dispute that metastases can be produced in animals by rough handling and squeezing of the primary tumor. Under these conditions regional and remote metastases, after operation, in human beings may occasionally be attributed to rough handling of the tumor before and during the operation. At any rate, the lesson is sufficiently obvious that the utmost gentleness of manipulation should be employed both in the examination of the tumor for diagnosis, and during its removal. For this reason, also, the axillary incision with the division of the axillary lymphatics, as the first step in the operation, has distinct advantages.

Remote metastases in bones, mediastinal glands, the liver and lung, occur late after operation, and provide some of the greatest disappointments in the surgery of breast cancer. It is probable that some of the more remote metastases are due, like some of the regional metastases, to manipulation before and during the radical operation. The greater number, however, are probably already established, although of microscopic size, at the time of the primary operation. The internal metastases of carcinoma can be detected only after a considerable period of growth, as they produce symptoms only by their interference with normal function, and a considerable bulk of tumor tissue must be present in order that function may be materially affected. Even the *x*-ray has been a disappointment in the detection of the early stages of internal metastases. A period of years is sometimes needed with a slow growing tumor before a sufficient mass of tumor tissue is produced

to make its presence evident, and yet these remote metastases produce some of the most distressing deaths from cancer of the breast.

The treatment of recurrent cases of cancer of the breast, and of cases too far advanced for even a palliative operation, is very largely symptomatic. Radium is apparently capable of destroying superficial nodules of cancer which are readily accessible, but has little effect on the deeper manifestations of the disease, as used at the present time. The use of strong filtered *x*-ray treatment, given with the Coolidge tube, appears to hold in check the deeper development of the disease more effectively than any other treatment. By the *x*-ray treatment sloughing and offensive discharges are diminished, and the patient's general condition, physical as well as mental, is improved. The ultimate results, however, are not materially affected, and the patient goes on to the fatal termination—the direct cause of death being dependent upon which vital function is most seriously interfered with by the internal manifestations of the disease. Finally, in the later stages of the disease resort to opiates usually becomes necessary, and, indeed, there would seem to be few cases more entitled to the relief of opium than those in the terminal stages of recurrent or inoperable cancer of the breast.

SURGERY OF THE MALE BREAST.

The male breast is structurally of the same constitution as that of the female, and is subject to the same diseases and new growths. The small size and imperfect development, however, of the male breast render it much less liable than that of the female to pathological conditions.

Malformations of the male breast are of the same nature as in the female. Amazia is equally frequent in both sexes, and is generally accompanied by defects in development of the chest wall. Micromazia, or incomplete development of the breast, may be considered the normal condition in the male. Supernumerary breasts probably occur in the male as often as in the female, but owing to the lack of glandular development their true nature is often not suspected. Gynecomazia has already been discussed under the diseases of the female breast.

Injuries of the breast or in the mammary region are more common in the male than in the female. Contusions are especially frequent, hematoma is not unusual, and abscess may result.

Diseases of the skin of the breast and of the nipple and areola occur as in the female, and do not require special consideration. Diffuse hypertrophy of the male breast, such as occurs in the female, is excessively rare if it ever occurs at all. Enlargement of the male breast is more likely to be due to a new growth. The acute mastitis of infancy and that occurring at the time of puberty are equally common in the male and in the female. Abscesses are unusual but may occur as a result of such infections. Abscess due to extension from necrosis of the ribs, or from empyema, affects both sexes equally, but at best is a rare condition.

The chronic inflammations of the breast, such as syphilis and tuberculosis, are rarely met with in the male, and chronic mastitis from other causes is also most unusual.

Cysts of the breast occur in the male as a great rarity. They are generally simply retention cysts due to traumatic or inflammatory occlusion of one of the larger ducts. Diffuse cystic disease, however, does occur, though rarely, in the male breast, and presents all of the stages, in miniature, of the disease in the female.

Tumors of the male breast are essentially the same as occur in the female sex. Their frequency is estimated at one or two to one hundred cases of tumor of the female breast. The most common tumors of the male are periductal fibroma and carcinoma.

FIG. 142.—Cancer of the male breast with axillary involvement and "brawny arm." Later amputated for spontaneous fracture due to carcinomatous invasion of the humerus. (Massachusetts General Hospital.)

Periductal fibroma of the male breast presents the same general characteristics as in the female, but occurs at a later period of life. It is benign and encapsulated, and should be removed.

Cancer of the male breast assumes most frequently the type of a scirrhus carcinoma. Metastasis in the axillary glands is generally present (Fig. 142). The symptoms and course of the disease are like those in the female, and the treatment is the same—by radical operation. Cancer of the breast occurs in men at the same time of life as cancer in the female breast. Cases of melanosarcoma and of rodent ulcer of the male breast have been reported. Other tumors of the breast, such as lipoma, enchondroma, angioma, adenoma, villous papilloma, and a number of different varieties of cancer have all been described in the literature as occurring in the male breast. Their, importance, however, should not be exaggerated, as they are extremely rare.

THORACIC SURGERY.

By CHARLES A. POWERS, M.D.

DEFORMITIES OF THE CHEST.

Congenital Deformities.—These may affect the dorsal spine, sternum and ribs; they are mainly defects although enlargements are sometimes seen.

Total or partial defect of the sternum, sternal fissure or perforation, is considered under the Surgery of the Heart and Anterior Mediastinum. Anomalies of the xiphoid cartilage are numerous and varied in character. They have no surgical significance but are of considerable anthropological import; they may, perhaps, be used as means of identification.

FIG. 143

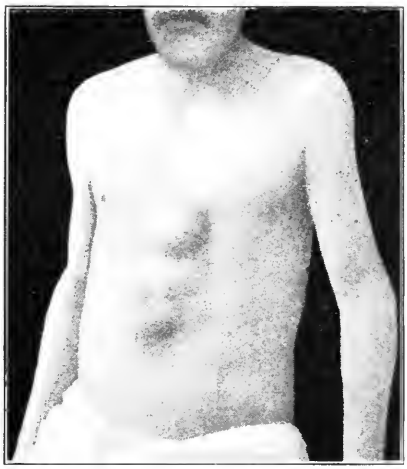


FIG. 144

FIGS. 143 and 144.—Cardiac ectopy from deformity in sternum. *a* (Fig. 143), profile view; *b* (Fig. 144), anterior view. (Anselme Schwartz, of Paris.[1])

Congenital deformities of the ribs are numerous and manifold. Supernumerary ribs are chiefly of the type of the so-called cervical rib, a condition which appears to belong alike under orthopedics, the pathology of bones and neurology. It will not be considered here. There may be a congenital defect of a rib, of two consecutive ribs, etc., and of portions of ribs and of rib cartilages. Such conditions may favor

[1] Chirurgie du thorax, Paris, 1912.

the development of a hernia of the lung and of ectopia cordis. If the defects occur beneath the pectoral muscles these muscles may also be defective. A study of a number of cases of anomalies of the ribs and cartilages shows no typical deformities although some of these have received the names of their discoverers. (*a*) Serb's deformity, in which the sternal ends of the first and second ribs are conjoined to form a single rib which articulates with the manubrium or with a special projection from the latter. (*b*) Luschka's rib, in which the anterior portion of the fourth, fifth or some other rib subdivides into two bones. (*c*) Cruveilhier's anomaly, adjacent ribs are united by a long strip of bone.

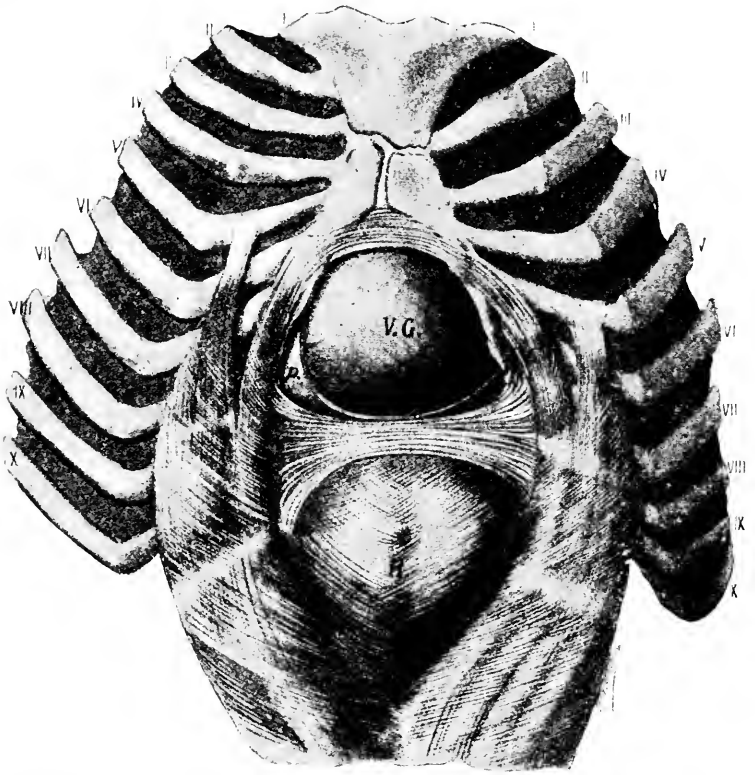
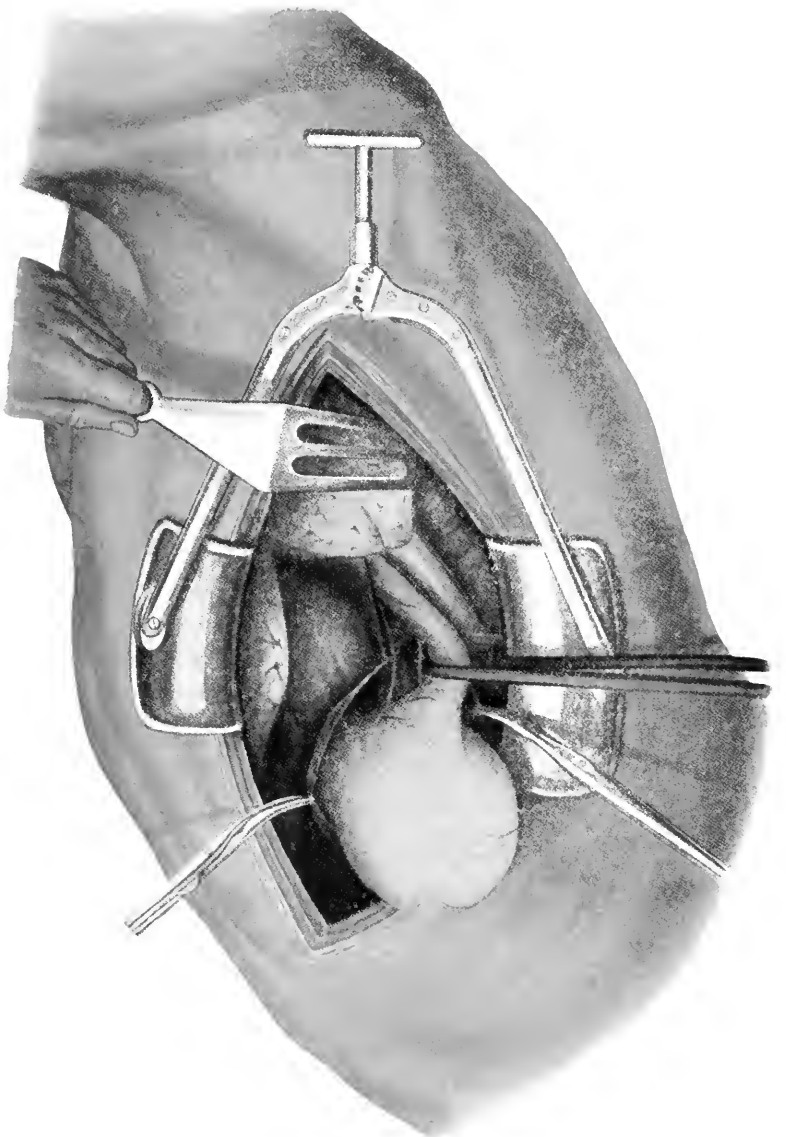


FIG. 145.—Partial cardiac ectopy and gastric hernia through a malformation of the sternum. (Anselme Schwartz, of Paris.)

The so-called floating rib (or abnormally movable tenth rib of Stiller) is said to be a part of the asthenic habitus; it has no especial surgical significance.

Congenital Funnel-chest.—Congenital funnel-chest is, in theory, a surgical affection although it may not incapacitate the individual. About 100 cases are on record. The deformity consists of a depression in the anterior thorax which roughly suggests a funnel, *i. e.*, broad at the outlet and tapering inward. The bony parts involved are the lower part of the sternum and the adjacent cartilages and ribs. The capacity may be that of an adult fist. It doubtless represents an error

PLATE III



Resection of the Cardiac End of the Stomach and Lower End of Esophagus for Carcinoma through a Combined Abdominal and Thoracic Incision. (Sauerbruch.)

of development. It is more common in males. From the fact that a similar condition can be acquired it has been assumed that so-called congenital cases may have been caused by pressure of the chin or heels in intra-uterine life. In adults, both compression from without and retraction of the lung from within, as in fibrosis of the lung, caused similar depressions. On the other hand the anomaly is sometimes familial; which would speak for a deep-seated congenital defect of development. A variety of the funnel-chest is the gutter chest, in which a deep groove replaces a funnel-like depression. The base of the groove is formed by the sternum while the walls are made by the costal cartilages.

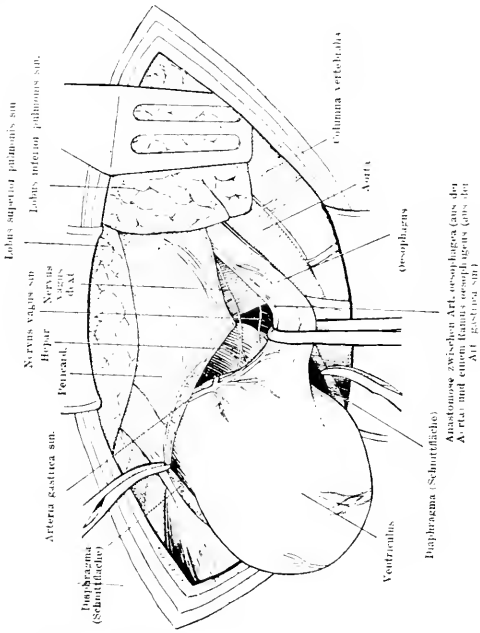


FIG. 146.—Anastomosis between Art. esophagea (from aorta) and a ramus esophageus (from arteria gastrica sin.)

In the recent years chondrectomy has been performed for funnel-chest.

Pigeon- or Chicken-breast.—This condition is the opposite of the funnel- or gutter-chest. The sternum, especially its lower portion, is prominent. The condition is due to rachitis. The primary seat of deformity is the ribs, which at the posterior aspect of the thorax are strongly convex, with an angulation at the junction of the lateral and anterior portions, the latter part being very slightly concave from the second to the eighth ribs. There is thus formed a shallow groove on either side of the projecting sternum and costal cartilages. Above the jutting ensiform cartilage there is a slight depression which corresponds to the site of the heart. Deformity of the spine may coexist. The condition is due to the plastic state of the bones common in rickets. As a rule, the subject outgrows the deformity and his efficiency is not impaired. In a few cases it has been necessary to perform chondrectomy to relieve dyspnea.

Congenital Thoracic Rigidity and Emphysema.—Simple mention is made of the fact that congenital rigidity of the costal cartilages due to premature ossification may, rarely, be encountered.

Congenital Narrowing of the Superior Thoracic Aperture.—This condition, and its surgical management are discussed under Tuberculosis.

THORACIC DEFORMITIES FROM DISEASE OF THE VERTEBRÆ.

These are secondary deformities in some of which surgical aid has recently been invoked. In scoliosis, kyphosis and spondylosis rhizomélique, the rigidity of the thorax may at times be overcome by chondrectomy or costectomy in order that the lungs and heart may better perform their functions.

Scoliosis.—Scoliosis or lateral curvature of the spine may be congenital or acquired, although it is now believed that much of the so-called acquired scoliosis is actually founded on a latent congenital condition. The causes are numerous and varied. In addition to the neuromuscular forms a large number of cases are secondary to some such unilateral deformity as wry-neck, Sprengel's deformity of the scapula, sacro-iliac disease, etc. In other cases general anomalies of the skeleton exist; rickets, acromegaly; or a spinal anomaly, Pott's disease. In turn, scoliosis causes other deformities, and in marked degrees the thorax is badly deformed—even more so than in severe cases of kyphosis. The vertebral curve is not a simple one but in general has an S-shape. The upper section, or dorsal curve, is usually convex to the right, while the lumbar curve is convex to the left. In addition there is a distinct rotation imparted to the spine. The dorsal curve, convex to the right, causes the ribs to bulge somewhat, and as this renders the scapula more prominent a boss or hump results. This is enhanced by a corresponding depression in the opposite scapular region. Anteriorly, on the contrary, the chest is more flattened on the right side and more convex on the left. The average patient with this deformity suffers much as a result of the displacement of the thoracic viscera. These are compressed against the abdomen; the heart is crowded to the left; both lungs, especially the right, are compressed.

Kyphosis.—This deformity, which is a bulging backward of the dorsal vertebræ, consists of two types known respectively as the round and angular. Angular kyphosis is another term for Pott's disease of the spine. When seated in the cervical or upper dorsal region the deformity is not apt to be excessive. In the mid-dorsal region kyphosis causes a deformity of the entire thorax; the ribs may be so depressed that they reach the ilium. The chest becomes shortened, as in severe scoliosis, flattened laterally and more prominent in front. It becomes very inelastic so that abdominal breathing is necessitated. Special forms of kyphosis which tend to immobilize the chest are the so-called heredo-traumatic form or von Bechterew's disease and the progressive kyphosis following fractures (Verneuil-Kümmel disease). The round

variety is also seen in Pott's disease, a number of vertebræ being affected (detailed description will be found under the proper heading in another part of this work.

Rigid Spine.—Two forms of spinal rigidity tend to immobilize the ribs; one of these is an ankylosis of the bodies of the vertebræ, as in spondylosis rhizomélique, while in the other the articulations of the transverse processes suffer. In either case the vertebræ become immobilized. These affections, which cause an ankylosed spine, are described elsewhere, and it is only necessary to state here that costectomies have been performed when the hindrance to respiration has become very marked.

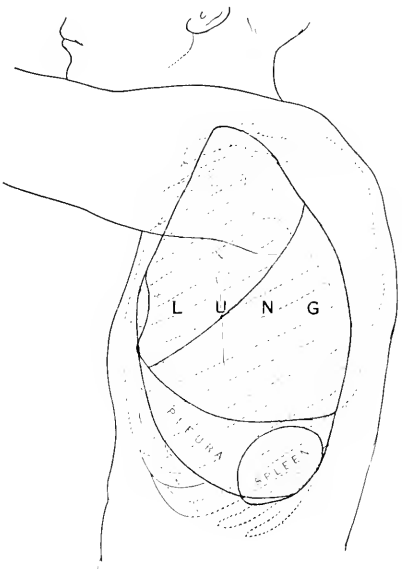


FIG. 147.—Side of thorax, showing surface markings of bones, lungs, pleuræ and spleen. (After Gray.)

Thorax Paralyticus.—This deformity has been described as both rudimentary and atrophic, two conditions which, naturally, often co-exist. Frequently spoken of as an abnormally flat chest, it is said by some anthropologists to represent a reversion to the quadrupedal type, in that it is longer, narrower, deeper and more rounded than the normal human chest. Thorax paralyticus in man shows depressed ribs and wide interspaces. A narrowing of the superior aperture of the thorax may be regarded as an expression of this deformity or as an isolated anomaly.

But little is known about the genesis of these chests or their relationship to the occurrence of pulmonary tuberculosis, but there is evidence to show that their structural development has not kept pace with that of the individual in whom the disease occurs.

The surgery of thorax paralyticus is that of pulmonary tuberculosis after the disease has developed.

Thoracic Contraction (*Pleuritic Scar Contraction*).—When a very large pleuritic exudate is absorbed without full expansion of the lung, the negative pressure in the chest causes the thorax to be displaced toward the lung. A somewhat similar condition occurs in an old empyema after an operative cure. Recovery is accompanied by a pronounced contraction of the thickened pleura and the adherent lung.

The symptoms vary; as a rule, the affected side of the thorax looks smaller and is drawn inward. Measurements show a difference between the two sides. The ribs touch each other and may overlap. The spinal column may show various types of curvature. Compensatory curvatures are present as a rule. On the affected side the various landmarks—shoulder, nipple, last rib—seem lowered. The head may lean toward the affected side. Without careful history, the condition may be confused with a rhachitis of the thorax.

When it occurs in a young subject, the condition may be outgrown in time. In older subjects, the process reaches its limits in six months, on an average.

No rational surgical treatment seems to have been developed as yet.

GENERAL PRINCIPLES OF INTRATHORACIC SURGERY.

Introduction.—Before taking up chest injuries and diseases as a whole, it seems appropriate to cast a glance over the general field of thoracic surgery; a field which has been broadened steadily and which promises very wide development in the future.

Surgery of the thorax failed to advance beyond a certain limit until definite study was made of the means of preventing the collapse of a given lung when an intact pleural cavity was opened. The study involved the equalization of pressure differences. Without this equalization the surgeon feared a fatality; indeed, until the so-called pneumothorax danger was completely or almost completely offset, fear, on opening the pleura, was far from imaginary.

This problem of opening an intact pleura is not parallel to that found in a given case of empyema, pleurotomy for the relief of which has been practiced since the earliest days. Early danger resulting from the evacuation of a pleural abscess, was chiefly one of infection and was greatly minimized by modern asepsis together with suitable rib resection. It is difficult to explain the occasional fatalities when the intact pleura is opened. Neither the size of the opening, nor the suddenness of the inrush of air, nor the rapidity of contraction of the given lung can, alone or together, explain the development of fatal shock. A fatality may occur even when all conditions seem favorable. Ordinarily, the smaller the opening the less the reaction.

An important period in the development of modern thoracic surgery was that of the decade 1895 to 1905. The early efforts were made

toward the prevention of pneumothorax and the inflation of the collapsed lung. Bazy,[1] in 1895, introduced the finger into the wound immediately on opening the pleura, thus occluding the wound itself and at the same time exploring the pleural cavity. At about the same time several surgeons introduced pneumopexy; drawing the contracted lung to the pleural opening and suturing it to the chest wall. In 1896 Tuffier and Hallion[2] discovered that the pressure difference between the exterior and interior of the lung was about 6 mm. of mercury. Further efforts toward the solution of the pneumothorax problem had to do with increasing the pressure difference within the lung, either by forced expiration of the closed glottis or by the insufflation of air; compressed air being used at times (Reference should be made to the fact that O'Dwyer's important discovery of the intubation tube was described in 1880.)

In 1893 Fell, of Buffalo, exhibited at the International Congress an apparatus designed for artificial respiration in opium narcosis. It consisted of a hand bellows, and a mask which fitted tightly over the mouth and nostrils. O'Dwyer modified the apparatus by substituting a laryngeal tube for the air-tight mask. Dr. Blum, of New Orleans, applied the Fell-O'Dwyer apparatus for re-animation in asphyxia neonatorum. He joined to the bellows a tube and bag of oxygen.

A little later Matas further modified the apparatus by substituting a pump for the bellows, thus giving an automatic respiration. With this apparatus an ordinary anesthetic could be employed. So far as may be learned, the first definite operation with the aid of such an apparatus, was performed by Milton,[3] of Cairo, in 1897. This operation was done for a mediastinal affection; the apparatus consisted of an intubation tube and a hand bellows. A very important resection of the thoracic wall for malignancy was done by Parham in 1898; the modified apparatus of Matas put in use as soon as the pleura was opened caused an expansion of the lung. In 1898, both Matas and Parham made important contributions to the literature of this important subject; indeed, the entire procedure owes much in its development to the careful work of these New Orleans surgeons, to whose names should be added those of their colleagues Souchon and Blum.

Küttner rightly considers all early efforts which are embraced under the head of "artificial respiration" as a necessary step in the development of pressure differences. He speaks with much commendation of the Fell-O'Dwyer apparatus and of the improvements made by Matas. A little after the appearance of the published work of Matas and Blum, Kühn[4] advised an insufflation tube, this tube going as far as the larynx. The important work of Friedrich, Sauerbruch and Brauer was commenced about 1904 and has gone on steadily. Finally,

[1] Asso. franç. de chir., 1895, ix, 79.

[2] Soc. de biol., 1896, iii, 1017.

[3] Lancet, March 27, 1897.

[4] Report in 1908. In this same year Volhard described a similar apparatus for re-animating animals which had been subjected to the action of curare, this by the insufflation of oxygen.

and as an exceedingly important contribution, Meltzer and Auer described their method of intratracheal insufflation anesthesia in 1910.

It does not seem possible to accurately estimate at this time[1] the relative advantages of overpressure and underpressure cabinets, or of the two combined, as ingeniously devised by Willy Meyer. Perhaps it may be sufficient to say that, at the present day, the tendency in this country seems to be toward the discarding of complicated cabinet apparatus, and the increasing employment of intratracheal insufflation anesthesia.

Since the great war there has been a definite trend toward the abolition of all complicated apparatus for anesthesia in chest cases. It has been found that the opening of a pleura is not so grave an operation as was formerly supposed, and while it is still true that debilitated persons do not stand pleurotomy well, the great majority of cases can be dealt with under open anesthesia. This is especially true when adhesions hold the pleural surfaces together, preventing collapse of the lung. In the absence of pleurisy of some duration it is wise to employ gas-oxygen anesthesia or a positive pressure apparatus as the Shipway for volatile anesthetics. — Ed.

A Preliminary Discussion of the General Principles of Thoracic Technic. Before the Cavity of the Chest is Opened. — *Preparation of the Patient.* Sauerbruch does not operate on his patients (deliberate, intrathoracic operations) without a formal preparation. He examines the heart and lungs by the ordinary physical diagnostic methods and by the use of the *x*-rays, looking especially for cardiac enlargement and for displacements. He measures the blood-pressure. If there is any doubt about the efficiency of the heart it is tested for its response to digitalis. He feels that the condition most to be feared is myocarditis with valvular incompetency. Bronchial catarrh, even the slightest, is an absolute contra-indication to operation because of the great danger of postoperative pneumonia. Bronchitis may be secondary to a cardiac lesion. It is best not to operate in the presence of intranasal and pharyngeal catarrhs. These, as well as bronchitis, must be treated, if necessary, for weeks the former, if necessary, by suitable operative procedures. Iron and quinine, once used as a routine in preoperative management, may be employed. (The treatment of troubles of the breathing passages may be left outright to the laryngologist and the rhinologist.) For a low blood-pressure before operation digitalis may be given several days in advance. Arteriosclerosis with a good blood-pressure is not a contra-indication to operation.

Blood-pressure in Thoracic Surgery. — As already mentioned, the blood-pressure should be measured before operation and, if too low, it may be brought up with suitable cardiac stimulants. Forlanini refrains from even making an artificial pneumothorax, until the blood-pressure is approximately normal.

[1] See paragraph on anesthesia in the section on Wounds of the Chest, p. 319.

From the analogy of the surgery of certain other organs, whenever a high blood-pressure is present an operation may be divided into two stages when it is thought probable that the first stage will afford temporary relief to some of the worst symptoms. In such cases, the blood-pressure may fall notably within a week or two, and the second stage may be completed under better auspices. Sauerbruch, however, pays little attention to arteriosclerosis or *high* blood-pressure when about to operate. He does not mention an increased risk of secondary hemorrhage. Increased tendency to fatal collapse is, he thinks, due less to high blood-pressure than to the cardiorenal lesions, which may accompany it.

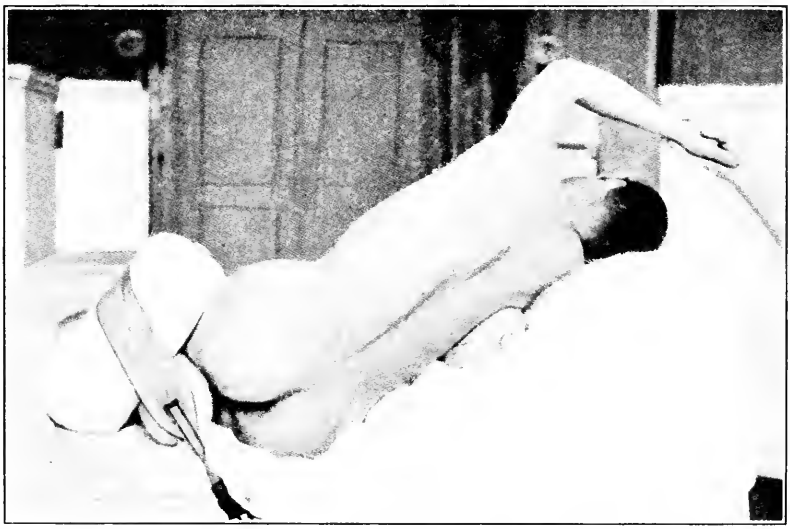


FIG. 148.—Position of patient in thorax operations. (Sauerbruch.)

Position of Patient.—Most thoracic operations require a special position for the patient. No suitable table has as yet been devised, as numerous difficulties are present here which are not encountered in other regions of the body. The form, size and diameter, the quality of the ribs, the situation of the disease-focus; all must be considered. Even with the same operation, it may be necessary to vary the position for different subjects.

As a rule, it is most convenient to place the patient on an ordinary table with a separate movable section for the head and chest. The patient is fixed to the table by cylindrical cushions or ordinary air cushions which do not impede respiration, since they readily yield to the motion of the ribs. This is of value when a man with but one useful lung is obliged to lie on that side. When the patient is in the lateral position the thighs form a right angle with the body, while two cylindrical cushions are braced against the buttocks with a broad belt. If the upper portion of the body is depressed, this position favors

drainage from the lungs when there are secretions in the bronchi. Elevation of the chest relieves dyspnea, etc.

Antisepsis, Asepsis.—There is not much to be said under this heading. In surgery of the thorax nothing must be allowed to chill the patient. The iodin-alcohol method of disinfection is good. It is quickly and thoroughly accomplished and does not burden the patient. Apparently it has no drawbacks. In emergency cases iodin may be painted on the operating field.

Disinfection of the surgeons' and assistants' hands, the dressings, etc., does not differ from that practiced in other surgical work.

Silk is chiefly used as a suture material; only in deep wounds of the lung and other conditions in which it does not give the requisite support, is fairly heavy catgut substituted.

Choice of Anesthetic.—The following general rules may be laid down for the use of anesthesia in thoracic surgery. Local anesthesia suffices for all extrapleural interventions, including resection of ribs and even maximal thoracoplasty. The technic of its use must be very thorough. If it falls short of the desired object, a little ether may be used.

In transpleural intervention local anesthesia is indicated, if the pleura is adherent, in the operative treatment of abscesses and gangrene of the lung. General narcosis is contra-indicated because it interferes with the evacuation of the fluid contents of the cavities. The lung itself is analgesic.

Whenever there is a broad opening to be made in the pleura general narcosis is definitely indicated because it prevents the reflex spasm of the glottis due to the pleural incision. The imperfect expiration raises the intrabronchial and intra-alveolar pressure, with the immediate result of increasing the labor of the right heart. Even the equalization of pressure is unable to control this type of respiration which mechanically injures the alveoli and thereby predisposes the patient to lobular pneumonia, etc.

It occasionally happens that the incision of the pleura in a non-narcotized patient causes death by arrest of the heart. This is perhaps connected with traumatism to the vagus or its branches.

In regard to the choice of a general anesthetic, ether is contra-indicated in the actual presence of bronchitis or pneumonia. Chloroform is best given in combination with oxygen. Timid patients may be given morphin. No scopolamin should be used if the patient must expectorate soon after the operation.

The use of the pressure-difference procedure favors anesthetization; very little anesthetic is necessary and postoperative nausea is less marked than usual. The blood-pressure remains unchanged. After the operation the patient is apt to be slightly cyanosed and to have severe postoperative pains which require morphin.

Local Anesthesia in Thoracic Surgery.—Garré, since he makes only a limited use of cabinets, recommends nerve blocking and infiltration in all subjects who are seriously ill or who have suppuration within

the lung; in which case pus or putrid matter may be aspirated into the lungs under general narcosis. This local anesthesia is, in a measure, contra-indicated if much handling of the pleura is expected, for reflex compressed breathing may be started as a result of a spasmodic closure of the glottis. The blood-pressure may be suddenly lowered. The field of intervention in thoracic surgery is so large that one must, so far as possible, depend on a nerve blocking of the intercostals. At the posterior portion of the chest, the intercostal nerve consists of a single trunk which lies in the middle of the intercostal space. At the juncture of the posterior and middle thirds, this trunk divides into two branches which run, respectively, along the lower and upper borders of the ribs by which the space is bounded. It may suffice to anesthetize the main trunk close to the vertebral column in order that the several posterior sensory twigs may become affected, as well as the anterior subdivisions. For the sake of thoroughness a further injection may be made into the intercostal space in the axillary line, thus anesthetizing both the upper and lower branches. The technic of this later maneuver is not simple. An infiltration wheal is first established, after which the syringe, plunged into the wheal, is turned upward and then downward; thus the branches can hardly fail to be blocked.

There is danger of injuring the pleura, especially in the act of infiltration; but this should be obviated by pushing the cannula forward, so that, in the process of infiltration, the injection fluid precedes the needle and forces the pleura backward. In any case, it should suffice to pierce only the external intercostal muscle. Infiltration is further extended along the incision lines. The solution employed may be a 0.4 per cent. to 0.5 per cent. novocain with adrenalin.

Anoci-association in Thoracic Surgery.—Forlanini blocks the intercostal nerves before making his operation for artificial pneumothorax, and Garré regards this blocking as commendable in operating without cabinets, and in all local anesthesia operations. (See Local Anesthesia.) So far as the writer knows (1919), Crile and his associates have not as yet developed an anoci-association technic in thoracic surgery. In the abolishment of pleural reflexes, a complete nerve blocking would seem indicated, as well as in all cases in which one desires or expects the lung to contract. In operating without pressure differences in traumatic cases in which it is desired to prevent a retraction of the lung, nerve blocking, in diminishing pleural reflexes, should in theory prevent the compressed breathing which results from coughing with a closed glottis. This phenomenon is regarded by some surgeons as conservative and hence, as one which should not be prevented.[1]

Diagnosis of the Degree of Pleural Adhesion.—In pulmonary tuberculosis some adhesions are almost always present; a perfectly intact pleura is very rare. These adhesions may result from old pleurisies and are then usually extensive—sometimes total. In other cases they form over foci of lung disease and are circumscribed. The best test for both

[1] At the 1914 meeting of the American Surgical Association, Ransohoff stated that anoci-association alone could prevent the shock of thoracotomy, etc.

forms is the state of the lung and the mobility of the free border. In the local type of adhesion the border is usually intact throughout, but in the diffuse form the entire margin may be immobilized. Whenever the pulmonary border is mobile, an artificial pneumothorax is possible—this mobility is the *sine qua non* for operation.

The methods of recognizing mobility or immobility are two—radioscopy and percussion. The former will show that, on deep inspiration through the rise and fall of the diaphragm—according to the size and clearness of definition—an idea of the degree of mobility of the lung margin can be obtained.

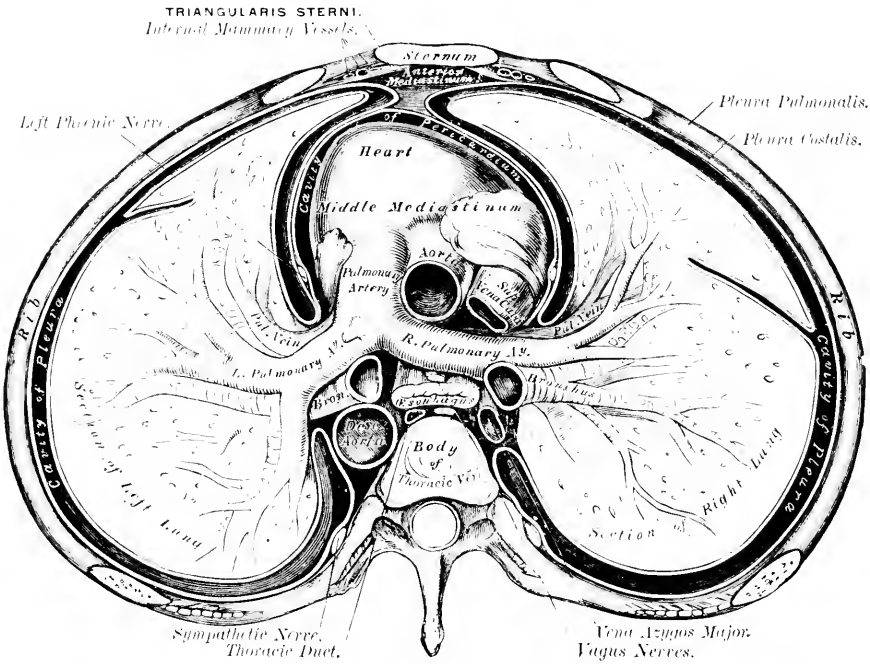


FIG. 149.—A transverse section of thorax, showing reflexions of the pleuræ. (Gray.)

Percussion must be done very carefully and very gently, using the solid viscera—heart, liver and spleen—as a background. The patient should fill and empty the lungs; to determine the maximum of inspiration he should lie flat on his side, while in forced expiration he should lie on his back. In this manner, it is possible to measure the exact degree of mobility of the entire border of the lung. According to this degree, the pneumothorax will be total or partial. If there is no mobility, as shown by these tests, one cannot at once conclude that a pneumothorax is contra-indicated, for the immobilization may be due to outside influences (chest wall, muscles). Conversely, the lung margin may seem to be mobile, *i. e.*, during inspiration flattening it may even be somewhat inverted. Both of these cases are rare.

Pressure Differences.—There is normally within the thorax a negative pressure of from 7 to 8 mm. of mercury, which is offset promptly, if a pleural sac be opened broadly, by the inrushing air. Meanwhile the pressure in the opposite pleural sac is undisturbed and is still negative. When one pleural sac is opened the lung of that side apparently collapses, but in reality retracts from its own elasticity. The pressure in the open pleural sac equals that of the atmosphere, while that of the closed side remains negative. Inspiratory efforts now cause overpressure on the affected side and, displacing the mediastinum, including the heart, compresses the intact side. Expiratory efforts, on the contrary, reduce the overpressure on the pneumothorax side, and the mediastinum with the compressed lung regain their normal boundaries. This pendulum-like behavior of the mediastinum greatly interferes with the interchange of gases. The respiration is at first convulsive from reflex apnea, but the retention of CO_2 soon leads to stimulation of the respiratory, cardiac and vasomotor centers. Respiration becomes slow and deep and the pulse slow and of increased volume. The contracted lung meanwhile becoming congested, the result of these various disorders is dyspnea.

Retarded respiration leads to a gradual cessation of expiration, as the intact lung becomes unable to empty itself when the thorax is in an expiratory position. Cessation of inspiration then follows, with death by suffocation. The circulation in the retracted lung is superior to that of its intact fellow. If both pleural cavities are opened, both lungs collapse and death supervenes rapidly from suffocation, although tracheal insufflation is able to maintain the respiration indefinitely.

From the clinical viewpoint, an incision of the pleura is at once followed by an inrush of air, so rapid as to cause a hissing sound. The lung contracts suddenly, its natural rosy color becomes a dark gray, and its glossy surface wrinkled. The retraction of the lung causes a reflex apnea, or arrest of circulation, which is followed by deep forcible breathing which lasts for one or two minutes (this stage is termed convulsive and irregular). Respiration then becomes quiet and progressively slow until it ceases. (This state may be antagonized by artificial respiration.) If, however, the opening into the pleura is smaller than the lumen of the trachea, the pressure differences are not much disturbed. For this reason punctures and small incisions for empyema (in recent years the establishment of an artificial pneumothorax) have always been practicable and regarded as minor measures.

In a large proportion of cases of diseased lungs there are extensive pleuritic adhesions. It has thus been found possible to attack the lungs surgically in a large number of instances without the fear or possibility of a collapse of the given lung.

True intrathoracic surgery has, however, dated only from the time when it became possible to prevent the collapse of an intact lung, upon freely incising the pleura. In theory this could be accomplished by two radically different methods: (1) The subject's body could be placed in a pneumatic cabinet with a pressure equal to the intrathoracic

pressure. (2) Air could be respired under pressure through an air-tight mask, or insufflated into the trachea. In either case, if the procedure were properly carried out, the lung could not well collapse upon incision of the pleura. As a matter of fact two separate schools of intrathoracic surgery have grown up upon this double foundation.

It is naturally possible to install an elaborate pneumatic cabinet from which the required amount of air can be pumped. The patient's head lies outside the cabinet and he may be anesthetized in the ordinary manner. The surgeon operates within the cabinet, unmindful of the slightly rarified air. The cabinet may be ventilated, lighted, equipped with a telephone, and may be roomy enough for assistants.

Such a cabinet could at once suggest itself in its numerous requirements, but it could hardly be evolved beyond a certain point. Its expense, bulk, isolation, etc., tend to limit its use, at this time, to certain hospitals.

The overpressure method was at first difficult of execution because it appeared to interfere with anesthesia, and, in fact, with the act of respiration in subjects with presumably crippled lungs. Herein it differs greatly from the underpressure method, for here the subject's breathing is not disturbed and he can be anesthetized in a simple way. The overpressure method was, further, very cumbrous at first, involving a small overpressure cabinet, with a detached anesthetic apparatus. This was succeeded by an air-tight mask in which a constant pressure could be maintained. Air or oxygen may enter the mask, and the former is mixed with anesthetic vapor in a special apparatus. The oxygen enters the mask by a special pipe. Waste air escapes by a special arrangement. The most vital portion of the apparatus is an elastic rubber bag which by preventing labored expiration insures a natural, easy respiration. (See special descriptions of apparatus.)

The Underpressure Procedure. The Zürich Cabinet.—This consists of a transportable, light metal framework which can be quickly erected. The walls, made of the thinnest, finest material, are readily screwed upon the framework. There is no separate floor, as the cabinet is moved about like a screen. On the lower extremity of the wall is a wide rubber flange, which, when placed on a flat floor, at once adheres by suction when the cabinet is pumped out.

The wall for the patient's head is so arranged that its lateral aspects bend outward in such manner that there is no interference with the operator, while the midsection carries in its aperture a head ring which can readily be moved up and down. The head is passed through this ring and the head aperture then narrowed by a certain device, which renders a neck cuff unnecessary. The head piece can be raised or lowered whenever it becomes necessary to move the body within the cabinet. A former argument against the underpressure cabinet lay in the fact that the operator and the anesthetist could not hear each other speak, but this has been obviated by the insertion of balloon fabric in the anterior wall. This does away with the need of a special telephone or speaking tube. The side pieces of the anterior wall have

windows through which the anesthetist can see the operation and the operator watch the anesthetist. The cabinet is ample within, and has a ventilating apparatus which prevents stagnation of air. It is so illuminated by electric bulbs that all portions are visible. When not in use the apparatus may be taken apart and folded up.

Sauerbruch[1] and others have extemporized underpressure cabinets by using small operating rooms, calking all of the seams and crevices and painting the walls. The air of the room is exhausted to the requisite degree. The head of the operating table is placed at the door which is specially constructed for the administration of anesthesia. (An air lock should be provided to permit of entrance to and exit from the room.)

The Dräger Combined Apparatus.—This was introduced in 1911 and was so termed because the administration of the anesthesia-oxygen mixture, and the methods of maintaining increased pressure and of automatically obtaining artificial respiration are combined in one. Either part of the apparatus may be switched on or off.

The apparatus for the automatic maintenance of artificial respiration is the pulmotor and is intended for use in suspended animation from gas poisoning, smoke suffocation, etc., as well as for the reanimation of stillborn infants. (See Artificial Respiration.) The apparatus as a whole has recently been so modified that by a slight increase in pressure, the principles of Volhard, Kühn and Meltzer may be carried out. The anesthetic portion of the apparatus is that known as the Roth-Dräger.

The overpressure apparatus consists of a cylinder of oxygen of 1000 liters capacity. The oxygen under compression is conveyed by a spiral pipe to the rest of the apparatus. A cylinder trap valve is opened allowing the oxygen to pass through the tube into the reducing valve which reduces the original high pressure to one of 8 atmospheres. The gas then enters the Roth-Dräger mask. Devices make it possible to cause either a vacuum or a high pressure in the mask.

Overpressure Apparatus.—Thus far several distinct principles have been utilized for this purpose, viz., a small cabinet or chest, a mask and an insufflation tube. The negative pressure is overcome by forcing air or oxygen into the lung; hence the overpressure apparatus must necessarily include or be associated with the anesthesia apparatus. The overpressure principle is very simply carried out, for it is only necessary that the patient's head be placed within a small air-tight chest in which is constantly maintained an overpressure of about 7 mm. to offset the negative pressure of the lungs. This alone rapidly inflates the lungs. The head-chest is kept filled by means of a small air-blast engine driven by a motor; this delivers, on an average, 700 liters of air-pressure through a tube of 6 cm. diameter to a large bellows. The air passes through a manometer and into the head cabinet where the pressure is shown by a water manometer. The air then escapes through a valve, the necessary resistance being furnished by a running weight.

[1] Ergebnisse d. Chirurgie, 1910.

The association of narcosis with overpressure complicates the device in a twofold manner; owing to the necessity of the anesthetist's

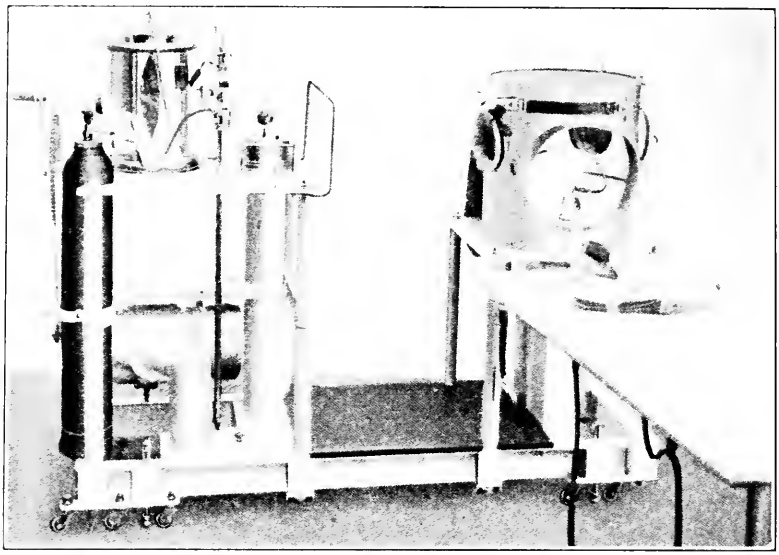


FIG. 150.—Overpressure apparatus of Brauer.[1] (Sauerbruch.)

arms being in the head cabinet, this is reduced air-tight by affixing a cap about the head, save the eyes, nose and mouth. This is necessary because only the head and neck are in the cabinet. Hence, to

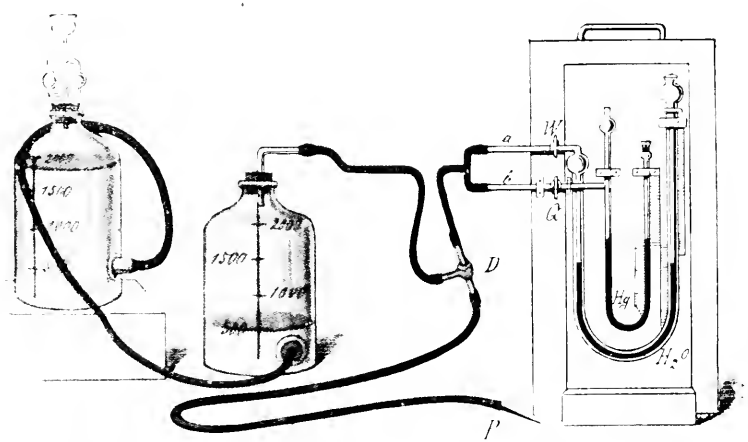


FIG. 151. Diagram showing the action of the Brauer apparatus. (Sauerbruch.)

prevent all ingress of air, the face cap is prolonged to envelop the neck. There are further openings in the head cabinet for the hands

[1] Ergebnisse d. Chirurgie, 1910.

of the anesthetist. When the head and hands are within the box the overpressure of the air tends to compress all the contents of the cabinet and prevent all leakage. For narcosis the simple methods most in use suffice, or the complicated Roth-Dräger mask may be associated with the pneumatic apparatus.

Much simpler than the small pneumatic cabinet is a special type of mask which can supply both overpressure and narcosis. A very large number of these cabinets have been devised. The desideratum is naturally to secure the combination of overpressure, narcosis and artificial respiration. The apparatus of Tiegel,[1] one of the oldest devised, is still in use. It requires a cylinder of oxygen with a pressure-regulating apparatus. This may be connected with a compressed-air cylinder, the two tubes being united and a switch apparatus provided

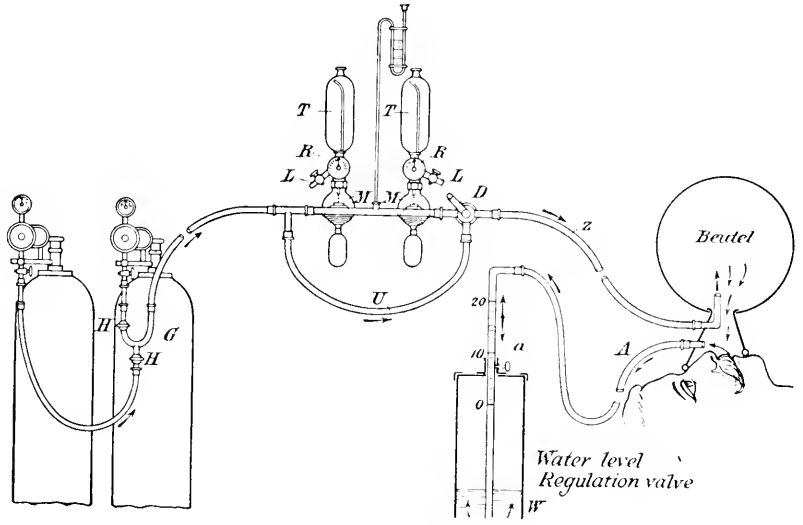


FIG. 152.—Tiegel's overpressure apparatus.

for delivering either kind of air or both kinds combined. The compressed air is used throughout to maintain overpressure, while oxygen is used, in part, for narcosis. Placed in front of the mask is a large rubber bag which serves to lessen the pressure differences between inspiration and expiration. The mask used is one which is applied closely to the face, rendering the nose and mouth air-tight. The tube of compressed air or oxygen enters it and the gases are delivered at a constant pressure. The air escapes through another tube provided with a water valve, so that the pressure in the mask is kept at a given tension. The water valve likewise shows the pressure differences in the apparatus. The anesthetic is dropped on the mask by means of a third or intermediate tube.

[1] Centralbl. f. Chir., 1911, No. 10.

The Willy Meyer Cabinet.—The idea of the Sauerbruch underpressure cabinet was further developed by Meyer[1] who devised cabinets representing both over- and underpressure, in other words, a universal apparatus for the application of differential pressure.

It consists of an inner, positive pressure chamber which can be used for narcosis, and a large external, negative pressure chamber, which serves as the operating room. The internal chamber can be used independently as an overpressure apparatus as both chambers have separate systems for ventilation and the estimation of pressure. One can enter and leave the external or negative chamber directly, because at the moment when the door is opened the pressure difference between the two chambers can be correspondingly graduated. The inner chamber, however, is provided with an air-lock. The operating, or negative-pressure room, is large and gives plenty of space for the operator and his required assistants. The narcosis cabinet of iron wire and balloon cloth keeps the anesthetist in close touch with the operator without the aid of a telephone or speaking tube.

Intratracheal Insufflation.– The original apparatus for intratracheal insufflation was very simple, consisting of a foot bellows connected by tubes with a bottle of ether and a mercury manometer. Air forced into the bottle became impregnated with ether vapor. It was forced into the larynx at a pressure of 15 to 20 mm., the tube being much smaller than the trachea, so that the etherized air could readily find its way out of the trachea. The intrathoracic pressure was increased to such a degree that interruption of the jet from three to six times a minute was required in order to enable the lung to contract and thus expel some of the residual air.

This constant inflow and outflow of air maintained the lung in a state of normal air exchange. Incidentally it was found that incision of the pleura was not followed by pneumothorax; hence, it is possible to use the apparatus instead of overpressure cabinets.

As modified for use in mankind, an automatic exhaust is added to prevent overpressure in the tubes. There is a tank for warming the gas. A motor is connected with the blower. Intratracheal anesthesia, in thoracic surgery, seems well fitted for the prevention of a collapse of the lung; further, it practically constitutes a general method of securing narcosis.

The method consists of the insufflation of air and ether into the trachea. To quote Meltzer, the essentials consist of the introduction of a flexible elastic tube deeply into the trachea, the tube being much smaller than the trachea itself. Through this tube a nearly continuous stream of air is forced, and this air returns through the unoccupied portion of the trachea. The pure air from without naturally forces outward some of the vitiated air in the bronchi, including that which is present in the larynx, pharynx and mouth. Thus, the insufflation of air not only does not interfere with ordinary respiration, but greatly

[1] Jour. Am. Med. Assn., 1909, liii, 1978.

assists it; as a matter of fact it is quite able to replace it for a time. Moreover, the recurrent air-stream tends to prevent the entrance of bacteria.

Intratracheal insufflation, then, seems to be a substitute for respiration; its association with anesthesia represents but one of its uses in medicine. The difficulties in introducing the tube into the glottis, even the impossibility of this without general narcosis, have not led to the preliminary performance of a tracheotomy. Elsberg (the first to use the method on human beings) advises a beginning general narcosis with ether. The patient then lies on his back, head downward at the end of the table, and a mouth-gag is inserted. The insufflation tube is passed with the aid of direct laryngoscopy, in which the instrument, really a speculum, is passed directly into the glottis.

In intrathoracic surgery the method may be used with the overpressure apparatus; indeed, some claim that the combination of the two methods gives an advantage over the underpressure method. (See Overpressure, etc., p. 213.)

Present Status of Pressure-difference Procedures. — Dreyer,[1] has attempted to reach an estimate of this by four routes, viz., clinical material, a study of the literature, animal experimentation and circular letters. In regard to experimentation, every one who has tested Sauerbruch's principle, recognizes in it a great advance in thoracic surgery. Whoever expects to do much experimentation should, therefore, have a cabinet and should use it as often as possible, for practice. The majority of those who use cabinets prefer the overpressure apparatus, even while regarding underpressure procedures as physiological. The overpressure apparatuses most commonly in use are the Tiegel-Henle, Shoemaker, the combination-apparatus of the Dräger Works, and that of Lotsch and Möllgard. In all intrathoracic operations, from beginning to end, there should be deep narcosis, for any act of struggling is disturbing to the operator and dangerous to the patient; further, at the end of the operation the lung more readily expands. For the same reason there should be sufficient air available in order that the inspiratory lowering of pressure may be restricted as much as possible. The Möllgard and Dräger apparatus both tend to maintain constancy of pressure. The Tiegel apparatus is provided with an extra large bag and a wider tube than usual. Those apparatuses are to be preferred which make it possible to apply a pure oxygen overpressure. (Oxygen does not require much overpressure during the intervention: 3 to 5 cm. water; the danger of inflating the stomach with a high pressure is therefore much lessened. The swallowed air can easily be removed after the operation.)

Another form of overpressure, differing in type, is the Volhard-Meltzer-Auer tracheal insufflation.[2] (Much used at this time in this country.) This has two difficulties: (1) The catheter must be neither too thick nor thin; if it be too thick there is no dead space; if too

[1] Berl. klin. Wchnschr., 1914, li, 1605.
[2] München. med. Wchnschr., 1908, No. 5.

thin much overpressure is wasted. (Insufflation can also be carried by other forms of overpressure apparatus.) (2) The introduction of the catheter; Jackson's laryngoscope is used; without some such resource the technic presents marked difficulties.

Drawbacks of Pressure-difference Surgery; Surgery Without Pressure Differences.—Pressure-difference cabinets are used most extensively in Germany. German surgeons, almost without exception, state that no one who has ever operated in certain classes of cases with pressure-difference apparatus, will ever dispense with them. Further, some thoracic surgeons who originally pronounced against them have become converts after testing them. On the other hand, Sauerbruch, who is chiefly responsible for their introduction, frequently operates without them, apparently reserving them for special classes of cases and for patients in which shock is most to be feared.

The testimony of the leading thoracic surgeons, in other countries, seems to be very largely against the use of over- and underpressure apparatus as unnecessary, cumbersome and expensive. Many surgeons, further, are warm advocates of the Meltzer-Auer intratracheal insufflation.

Is a Pressure-difference Apparatus Unphysiological?—According to Garré, in none of the methods employed in maintaining pressure differences is the gas exchange normal. The respiration occurs with the chest in the inspiratory position, and strong expiration is lacking; hence residual air which is poor in oxygen, tends to accumulate.

In the Meltzer-Auer procedure, air or oxygen forced into the lung under pressure ventilates the lung and mechanically forces out the residual CO_2. Thus a quasi-normal exchange of gases is produced.

Even in the Sauerbruch cabinet, breathing is said not to be physiological. The negative pressure causes a more or less permanent position of the vocal cords on inspiration. There is no strong expiration. If the patient were under local anesthesia the breathing might proceed naturally, but he is under general narcosis.

All overpressure apparatuses cause the same type of respiration as insufflation.

Inconveniences and Dangers of Pressure-difference Procedures.—Garré states plainly that he is far from being a partisan of this method, and that he has done most of his operations without recourse to it. His objection is, in part, that asepsis cannot be properly carried out in the use of the neck cuff in the underpressure procedure. (This objection is absent in the overpressure procedures.)

In the use of masks in the overpressure procedure there is danger of vomiting. Should the patient start to vomit it will be necessary to remove the mask, whereupon pressure changes will be in evidence. As a result of this the operation may be delayed. Further, vomiting may be feared because of the danger of the aspiration of vomitus. In insufflation, under proper conditions, vomiting should rarely occur.

Any differential pressure apparatus may break down at a critical

moment. Hence, operators must hold in readiness tampon material for the prevention of a total collapse.

In incomplete collapse of the lung, pus or blood can be aspirated from the lung to the pleura and *vice versa*. Since collapse of the lung leads to impoverishment of the blood in oxygen, insufflation of oxygen into the lung is indicated.

Pressure differences sometimes cause acute dilatation of the stomach. This may happen when the head and neck are under different pressures (as when the manchette lies close beneath the chin). When the pressure on the neck is relieved, the higher tension of the air leads to a blowing up of the esophagus and the stomach. Acute, fatal gastric ileus has occurred. The meteorism in the intestines may compress the diaphragm and heart, and thereby interfere with cardiac activity. Secondary infections of the lung may develop.

Inflation of the lung compresses the lung capillaries and renders difficult the work of the right heart. Hence, in the case of a weak or diseased heart and in emphysema of the lung the pressure difference should be very slight; not over 4 to 5 mm.

Pressure differences which exceed 10 or 12 mm. should be avoided in all chest and mask apparatus, although, in insufflation, a pressure of 20 mm. may be applied unhesitatingly if the stream of air is interrupted now and then. Garré regards a prolonged intervention under narcosis with pressure difference as dangerous. Patients may die at the close of such intervention, and even before such close, with no evidence of any causal factors save a so-called "shock." The lungs inflate fully but there is an absence of strong expiration. The residual air is poor in oxygen and the residuum tends to increase constantly. The blood becomes more and more charged with CO_2 until it begins to act upon the respiratory and vagus centers. A vagus pulse then develops, followed by a lowered blood-pressure and a pulse becoming uniformly rapid. Respiration is undisturbed, a favorable symptom calculated to deceive. As a matter of routine, in these long operations, Garré always keeps oxygen on hand for insufflation, and the lungs are often allowed to go to the position of expiration.

Garré implies that the dangers from pneumothorax are not so formidable as to force the use of pressure-difference apparatus. He has made use of the apparatuses of Sauerbruch and Brauer, and feels that they are valuable in large thoracoplasties and in cases of injury to the lung. They do not seem necessary, however, for operations in gangrene, abscess, bronchiectasis, etc., when it is desired to locate a given focus.

The Writer's Attempt to Estimate the Value of Pressure-difference Procedures.—It is not easy to make this attempt. A careful review of the literature, together with a not inconsiderable surgical observation in this country and in Europe, leaves the impression that the entire subject is as yet undetermined. At this time, it is probable that Sauerbruch has had the greatest experience in thoracic surgery; it has already been said that he uses pressure-difference cabinets in certain

procedures and discards them in others. With the exception of Willy Meyer,[1] whose work should be accorded the greatest credit, American surgeons seem to look with disfavor upon all cabinets. Some have installed them only to discard them later. Robinson,[2] whose experimental work on animals and actual work on humans have been very considerable, told the writer in 1915 that he believes cabinets devoid of practical value. The surgeons of no country have traveled for observation and improvement more extensively than have those of America, and these latter are definite partisans of the intratracheal insufflation procedures. The whole situation must be considered as in a formative stage, remembering ever that the surgery of tomorrow will be better than is that of today, even as the surgery of today is better than was that of yesterday.

INJURIES OF THE THORAX.

Contusion of the Thorax.—This term implies the combined results of blunt violence in all possible degrees, from the merest bruise to severest compression and crushing. The term contusion, however, can be applied only to sudden violence. If the thorax is compressed very slowly no severe damage need actually occur, even if the sternum be forced nearly as far backward as the spine. The organs readily adapt themselves to the changed conditions.

While the minor phenomena of contusion need hardly receive mention, the violence in extreme cases is of much importance. For example, a man may be struck on the chest by a heavy, thrown stone or other projectile; he may fall on his chest from a height, or be struck, while lying supine, by a heavy, falling object; he may be run over by a heavy vehicle or compressed between buffers.

This type of injury can damage any of the thoracic structures or contents, and, naturally, may injure nearby organs. The parts which give way most readily are the lungs and pleura. While sudden violence tends to cause a collapse of the lung, spasmodic closure of the glottis antagonizes the collapse and the lung may rupture at some point, generally into the pleural cavity. These ruptures are followed by hemorrhage, blood being coughed up or forming a hemothorax. The victim is usually badly shocked, presenting all of the phenomena of collapse.

When pneumothorax develops the air escapes from the lung only when a large bronchial twig is ruptured. Pneumo- and hemothorax may occur alone or in combination.

Rupture of the diaphragm may be followed by the prolapse of some abdominal viscus into the thorax (see Thoraco-abdominal Wounds). Emphysema (subcutaneous) may occur without the coexistence of fracture. Similarly, a hernia of the lung may take place in the absence of fracture.

[1] München. med. Wchnschr., 1909, No. 47.
[2] Surg., Gynec. and Obst., March, 1909, p. 255.

These early symptoms are often followed by other delayed phenomena. When pneumothorax does not soon disappear, it may cause marked pressure symptoms. Absorption of blood from a hemothorax may cause a temperature rise.

So-called "traumatic breathing" which is present at the outset (cyanosis, dyspnea, etc.) is often followed by severe pain. Infection of a collection of air or blood in the pleural cavity may lead to a traumatic empyema. Contusion-pneumonia is known to develop in some cases.

Prognosis.—These injuries, while causing a high mortality, often end favorably without sequelæ. Exact statistics of uncomplicated injuries seem to be wanting.

Treatment.—The treatment consists of rest in bed with external applications of ice. If much shock and hemorrhage have occurred, saline infusion and cardiac stimulants are indicated; if the hemothorax is very extensive it should be aspirated, but this only after suitable delay, for the compression symptoms may not become aggravated. Dyspnea may sometimes be controlled by morphin.

Thoracotomy for internal hemorrhage has regularly been done in the great war.

Commotion of the Thorax.—This is a concussion unaccompanied by external or internal evidence of injury. A patient may receive a sudden blow as from a stone on the chest, and feel few, if any, effects. Others, from the same violence, may gasp and fall, yet without serious consequences, while others are severely shocked. Some recover from this state rapidly, while in other cases the state of collapse is variously prolonged. Death has occurred in this way.

Judging by effects rather than by the degree of violence, two types of commotion are readily recognizable, to wit: mild and severe.

In the severe cases, the violence nearly always occurs over the sternum, so that the heart, rather than the lungs, bears the brunt. The exact mechanism is as yet unknown. The collapsed condition is due to a sudden lowering of the blood-pressure, but whether this is directly or indirectly due to irritation of the vagus, is not known. If the violence be severe enough the heart's action may be arrested in diastole. That the blood-pressure may remain subnormal for a long period is held to be due to active congestion of the mesenteric vessels as a result of irritation to the depressor and sympathetic nerves.

Death is believed to be due directly to changes in the circulation in the nervous centers, from arrest of the heart's action, and from lowering of the blood-pressure.

When a patient is injured by blunt violence over the sternum or anterior chest wall, contusion and commotion may coexist to some degree.

Treatment.—The treatment is that of shock.

Suffocative Compression of the Thorax.—This accident, when fatal, constitutes one of the types of suffocation. Compression may not be restricted to the thorax but may involve the abdomen, which tends

to force the diaphragm upward and immobilize it. Further, compression of the abdomen alone may cause suffocation. This type of accident is of great forensic importance because it gives rise to a characteristic syndrome. A sudden, severe compression of the thorax forces the blood into the veins which form the superior vena cava, and since this system of veins is not provided with valves, extensive punctiform ecchymoses, or petechiæ, are caused in the head, face, conjunctiva, neck, shoulders, upper arms and upper part of the thorax. The individual ecchymoses are very small, but they are so closely approximated that the entire integument appears cyanotic. The subject is comparatively a recent one in literature, no complete systematic accounts having appeared until 1899, although scattered observations were made as far back as 1837. The material on record consists, very largely, of crushing injuries occurring in panics, in which individuals were densely packed together or trod under foot. Any force that causes a sudden and violent compression of the trunk may produce the same injury; the "avalanche" type of accident, or that due to the passage over the body of a heavy vehicle. The violence need be but a few seconds in duration. Analysis of a small number of cases shows that the thorax alone was compressed in 8 cases, the abdomen in 3 and jointly in 11. Animal experimentation has shown that this type of injury can be produced at will.

The age of the patient possesses much significance in these cases. (Compression fracture of the thoracic cage is a separate condition.) The great majority of cases occur in the young, before the period of calcification of the costal cartilages. Of 16 cases cited by Schwartz,[1] 9 occurred before the age of twenty-one and five in the third decennium. Only 2, or $12\frac{1}{2}$ per cent., occurred after the age of thirty.

The reason the greater part of the upper extremity escapes the ecchymosis is evidently due to the presence of valves in the veins of the arms. The brain, also, is for the most part spared, but in rare cases, retinal and other intra-ocular hemorrhages are seen; while orbital hemorrhages are fairly frequent. The veins which form, or discharge into, the inferior vena cava are well provided with valves, and the lower extremities rarely show the presence of ecchymoses.

The purely mechanical theory in regard to these ecchymoses is by no means final. Some writers affirm their belief in the existence of vaso-dilation in the cervico-facial region as a result of contusion of the splanchnic nerves. Others deny that compression of the trunk can empty the large veins without causing severe visceral lesions, which, we know, seldom develop. To explain this compression they believe it necessary to invoke the coöperation of the abdominal muscles and the reflex closure of the glottis. The enormous increase of intrathoracic and intra-abdominal tension thereby produced would then act as the direct cause of the expulsion of venous blood; the compression of the trunk being the indirect cause. The immunity of the cranial sinuses

[1] Chirurgie du thorax, Paris, 1912.

from rupture is probably due to the fact that their walls are not distensible, so that the blood forced into them is simply passed through and reënters the veins of the face by the natural anastomoses.

Symptoms.—Patients thus crushed sustain more or less shock, the pulse becoming small and the respirations short and irregular. Consciousness may or may not be lost. The face and neck at once assume a blue or violet hue. In a typical case, there is a sharp line of demarcation which corresponds to the upper margin of the shirt. This is not a coincidence, for, curiously, if the shirt is unbuttoned at the time, the ecchymoses descend much lower and may reach the abdomen. The face, and especially the eyelids appear swollen, and there may be exophthalmos due to intra-orbital hemorrhage. Escape of blood from the nose and mouth, sometimes present, will perhaps suggest fracture of the base of the skull, especially if the patient be unconscious.

Prognosis.—While nearly all reported cases ended fatally, death by no means always follows. In benign cases the patient may rapidly recover, but a week or ten days is required for the absorption of the ecchymoses proper. In a typical case the ecchymoses may be localized —especially in the eyelids and conjunctivæ, extending outward upon the temples. Epistaxis may coexist.

Treatment.—The only active treatment is that for shock.

Fractures of the Ribs.—This injury is of frequent occurrence, statistics showing that it constitutes over 10 per cent. of all fractures. The kind of violence producing it is similar to that which produces contusions and compressions, but, while the latter occur in the relatively young, fractures are particularly apt to take place after the age of thirty-five. Naturally, the same violence often causes both contusion and fracture. The diminished resistance of the ribs, which tends to increase with age, is due to a twofold cause—ossification of the costal cartilages and rarefaction of the bones. Over one-half of the cases of fracture of the ribs occur after the age of forty. The incidence of sex is: male, 5 or 6; female, 1.

The causes, as elsewhere with fractures, are direct violence and muscular action. The forms of direct violence are numerous. Falling upon a projecting object, buffer accidents, automobile injuries, avalanche accidents, crushing in crowds, blows, etc., are familiar examples. Muscular action seldom figures as a cause and generalizations concerning this are based on but few cases. The lower ribs, nearly always a single rib, are involved in the majority of cases. These fractures, at times, occur during the latter months of pregnancy, even with no definite history of violence. They may, rarely, follow violent coughing or sneezing or other muscular effort. In rare cases these fractures are not only multiple but bilateral.

Victims of intrathoracic disease, elderly people and alcoholic subjects, are particularly prone to fracture.

There are two distinct mechanisms in direct fractures. In the first form the violence directed against the rib tends to bend it or force its convexity inward. When it breaks, the fragments project against the

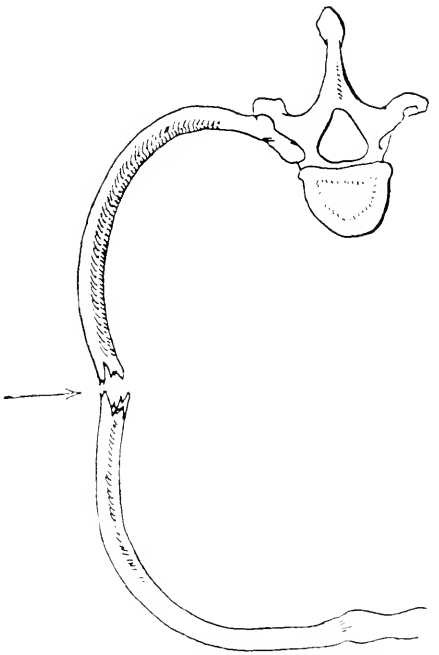


Fig. 153.—Internal fracture of rib. (Anselme Schwartz, of Paris.)

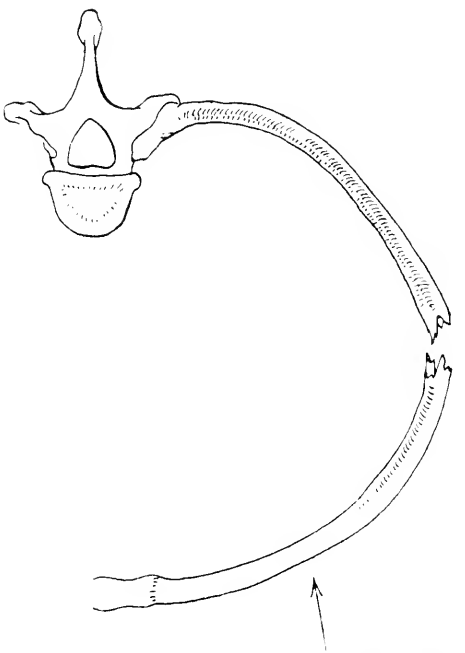


Fig. 154.—External fracture of rib. (Anselme Schwartz, of Paris.)

pleura and lung. This mechanism is seen in blows upon the chest. In other cases, as in crushing injuries, violence may be applied over the front of the chest, compressing it. The ribs are then bent outward and when fracture occurs the fragments tend to project into the subcutaneous tissue and skin. If the interior surface of the thorax is compressed, the break tends to occur in the anterior third of the rib, near the cartilage. If the violence is received at the back of the chest, the ribs tend to break near the spine. These findings, confirmed by experiment, do not agree with theoretical considerations.

But little is known of the mechanism of fractures from muscular action.

The ribs most commonly broken are the fourth to seventh, since these are most exposed to violence. The upper ribs are protected by the clavicle and by muscular masses, while the lower ones are much more yielding and thus undergo fracture less readily.

There are several forms of incomplete fracture, all of which occur infrequently. They appear as fissures of the outer bony plate, as greenstick and subperiosteal fractures. The majority are complete, even though there is no discoverable separation of the fragments. It rarely happens that a rib breaks transversely or in a short line; as a rule, the fracture is oblique and the fractured ends are dentated so that overlapping does not readily occur.

With but little violence, or localized violence, it is usually a single rib that is broken, but if the entire thorax be compressed, several contiguous ribs give way, thus giving rise to the mobilization of a considerable portion of the chest wall. Bilateral fractures occur under the same conditions.

The violence which serves to break several contiguous ribs may, on the contrary, cause notable displacement. The ribs are forced inward and rise with each inspiration. When a solitary rib is broken displacement of the fragments rarely occurs, at least, in the personal observation of the writer. Other surgeons of wide experience, however, state that displacement is by no means infrequent. This divergence of opinion is best explained by the view that displacement is never marked, and when present may undergo spontaneous improvement.

Callus forms in a majority of cases, and when there is much displacement, as in multiple fractures, it may be exuberant. Pseudarthrosis rarely occurs, and when present gives rise to little or no disturbance.

Symptoms.—Pain and dyspnea are the most constantly present, the latter arising from a painful inhibition of inspiration. Pain is usually intense and is much aggravated by a slight movement, especially by such acts as coughing and sneezing. Respiration thus instinctively becomes shallow and superficial. The pain and dyspnea after a bad contusion, likewise may be equally severe.

Deformity is not usually in evidence save in certain multiple fractures. At the seat of fracture an induced pain is elicited by pressing the fingers along the ribs: this tenderness and pain are quite characteristic. The tender point may be directly over the break or at a point

somewhat distant from it. Mobility is not always obtained. Crepitus is most readily elicited by having the patient cough, and is detected by pressing the palm over the supposed break. Naturally, the more extensive the injury the simpler is the diagnosis.

Diagnosis.—In addition to the diagnostic points already enumerated, the *x*-rays should always be employed to make or confirm a diagnosis.

Complications.—Fractures of the ribs should unite permanently in three or four weeks, but at times complications occur, healing is retarded, and the fractures themselves are overshadowed by the collateral injuries.

The complicating lesions in the superficial tissues of the chest wall are insignificant—a contusion or a hematoma. The latter, at times, however, provides a focus for infection. A rare complication in the chest wall is a rupture of an intercostal artery accompanied by a traumatic aneurysm, or the free effusion of blood into the pleura if the latter be lacerated.

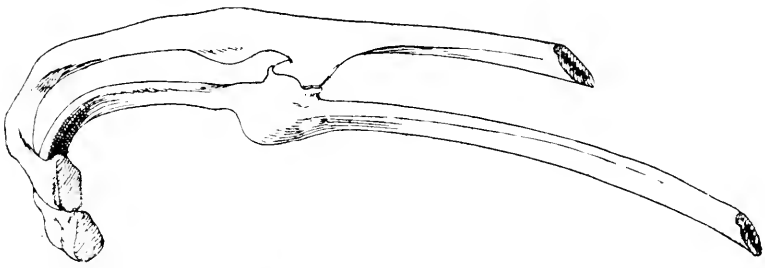


FIG. 155.—Fracture of two ribs with vicious union. (Anselme Schwartz, of Paris.)

Fractures of the ribs, *per se*, or the violence which causes them, may occasion pneumothorax of a benign character. Air escapes from the torn lung into the pleural cavity; the tear often closes spontaneously thus permitting the absorption of the extravasated air. Pure pneumothorax is rare, for in most cases blood is present in the pleural cavity. This is of the valvular type and serious. In exceptional cases pneumothorax may be due to a laceration of the parietal pleura. In the condition mentioned above (hemothorax from a ruptured intercostal artery), the pleural cavity may become filled with blood. Inspiration causes aspiration of the blood into the cavity by changing the pressure conditions.

Subcutaneous emphysema occurs in about 5 per cent. of all rib fractures. The air enters the tissues from a pneumothorax or directly from the lung, when the latter is adherent. When the lung is free it will retract and a pneumothorax develop; the air then escapes from the pleura into the subcutaneous tissue and diffuses to a greater or lesser extent. It may become universal or subtotal. When the pleura is adherent the air passes directly from the lung into the subcutaneous tissue. In the majority of cases the emphysema, however produced, remains localized and recovery is spontaneous.

Hernia of the lung, traumatic emphysema, etc., are complications which are considered elsewhere.

Treatment.—In the exceptional instances of multiple fractures, of bilateral breaks or of bony lesions complicated by emphysema, pneumothorax, hemothorax, etc., rest in bed for a longer or shorter space of time may be necessary. In the ordinary case of fracture of a single rib ambulatory management is proper, the chest wall at the seat of fracture being immobilized, so far as this is possible, by adhesive strips carefully applied. These strips should be of zinc oxide plaster about three inches wide, the successive layers overlapping each other and extending entirely around the chest. The strips should embrace the chest wall above the fracture and well below it. They should be very tightly applied, at the time of forced expiration, with the patient in the standing or sitting posture. At the end of a week, the first dressing is to be renewed. If the chest is a hairy one it must be shaved before application of the plaster. Three or four weeks usually suffices for firm union although delayed union sometimes occurs, especially in elderly people and in those whose bones are very easily broken. Ordinary roller bandages, binders, etc., are of little aid in the treatment of broken ribs.

In case a number of ribs are broken, the mechanism of breathing may be so completely interfered with that there is danger of a fatal result. Because of inability to maintain respiration, the motion of the chest wall may become extremely erratic, so that it will be impossible to count the respiration. The secondary effect upon the heart will cause an increase in the number of beats to two hundred or over per minute, and the patient may be in great danger of losing his life because of an inability to restore effective respiratory action. In such cases, it is well to apply rubber adhesive plaster strips, not to exceed two inches in width, and overlapping about one-half of the width of the plaster at each turn and forming an adhesive plaster corset extending from the axilla to the border of the tenth rib. The fixation of the chest wall obtained in this manner will permit respiration to be established by means of the diaphragm, which frequently results in an almost complete restoration of the patient within a very short time. The editor has seen a number of apparently hopeless cases of this condition restored by this simple method, which is infinitely more effective than if the rubber strips are placed only part way around the chest.

Fractures of the Costal Cartilage.—This lesion is of less frequent occurrence, the etiology being the same as that for fractured ribs. The patients are nearly always males, and the cause is generally direct violence. Muscular action may be a cause.

The cartilages usually broken are the seventh to the tenth, the break occurring nearer to the rib than to the sternum, and often at the junction of the cartilage with the rib. A broken cartilage may be comminuted. The fracture is nearly always vertical, the cartilage breaking transversely; displacement is the rule, one fragment often overriding the other. Ordinarily the sternal segment overrides the costal.

Symptoms.—All of the symptoms of fractured ribs are present save crepitus, absence of the latter being due to the smooth character of the fractured ends.

These fractures undergo repair in several ways; a fibrous or fibrocartilaginous tissue may form between the fragments, or regeneration may occur directly from the perichondrium.

Prognosis.—The prognosis is good.

Treatment.—Adhesive strapping, as in fractured ribs.

Dislocations of the Ribs and Cartilages.—Dislocations of the ribs at the vertebral articulations, and of the cartilages at the sternal articulations have been known to occur, but are of such infrequency that but few cases have been placed on record; according to Schwartz[1] but 9 of the first named and 12 of the latter. Even more rare are dislocations at the costochondral articulation, of which but 4 are on record.

Costovertebral dislocations have all occurred in young subjects and as a result of extreme violence, this having been sufficient to cause the death of 7 out of 9 cases. In a majority of the cases a diagnosis was not made during life. The lower ribs, especially the eleventh, seem predisposed to this rare form of dislocation.

Chrondrosternal dislocations, on the contrary, are benign and occur in the upper ribs. The cartilage projects beside the sternum; it is readily reduced and held in place by adhesive strips.

Costochondral dislocations occur chiefly in the sixth to ninth ribs. Most of them are due to violent muscular contraction, probably of the transversalis abdominis muscle and diaphragm. The cartilage may be displaced forward or backward. It should be reduced and immobilized.

Fracture of the Sternum.—This lesion is rare, especially in childhood and adolescence. It is due, in the great majority of cases, to sudden external violence and therefore rarely occurs by itself. The causes are those of thoracic injuries in general: crushes, buffer accidents, projectiles, horse kicks and the like. Injury to the spine may coexist. Conversely, direct violence to the spine may injure the sternum. The mechanism is not always clear, especially the relative parts played by *contra coup*, muscular violence, increased spinal extension and direct impact. In some of the mild types of injury, perhaps isolated, the part played by muscular traction seems evident. These are of the type of laceration fracture, and of those due to heavy lifting, hanging by an arm, etc.

The site of the fracture may be at any part of the sternum, but it is generally at the junction of the manubrium with the sternum proper. Fracture at the lower of the two articulations is very rare. The fractures are very seldom double, oblique or incomplete. Transverse single fracture, complete, is the ordinary type.

Fracture of the sternum is generally sufficiently obvious on inspection and palpation. In most cases, the violence is inflicted upon other portions of the chest and its contents, and the symptoms vary with the case.

[1] Chirurgie du Thorax, Paris, 1912.

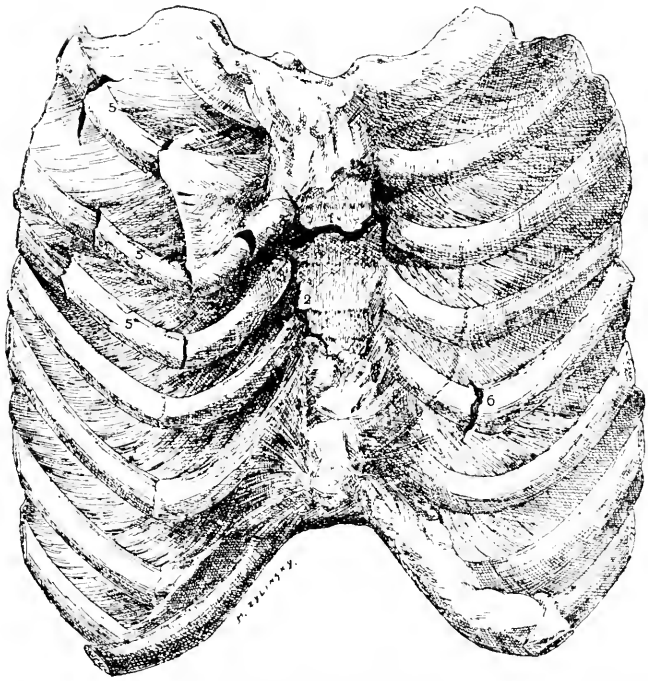


FIG. 156.—Transverse fracture of the sternum accompanied by fractures of several ribs. (Anselme Schwartz, of Paris.)

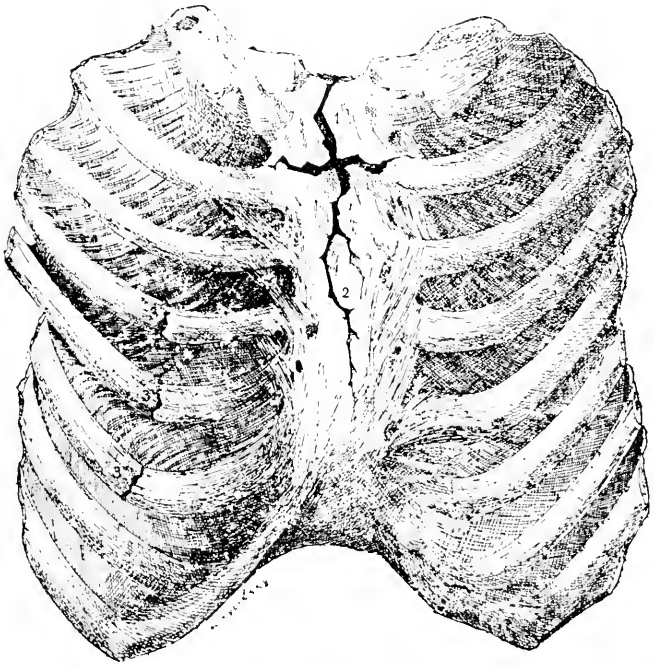


FIG. 157.—Cross-shaped fracture of the sternum. (Anselme Schwartz, of Paris.)

Diagnosis.—Diagnosis is based on the separated segments of bone, together with crepitus, pain and extravasation of blood *in situ*.

Fracture of the xiphoid cartilage results in pain and displacement. *X*-ray pictures should be made.

As a rule these sternal fractures unite rapidly with but little callus formation. In marked displacement it may be difficult to reduce the parts, but even in the absence of reduction union occurs.

Treatment.—In the simplest type of lesion no retentive dressings are indicated. The patient lies in bed with simple dressings, and, if necessary, a sedative for the cough. If the fragments overlap slightly, the patient lies on a double inclined plane thus overstretching the spine; the overlapping may disappear spontaneously in a few days. If the overriding is very extensive, the projecting end of the bone may be chiselled off, after detachment of the periosteum. Replacement will then, as a rule, be made easily.

Union generally occurs in the ordinary length of time.

Non-penetrating Wounds of the Thorax.—Under this heading may be included burns and scalds, which occur occasionally in severe degrees on the back or chest. These are most apt to take place in irresponsible subjects such as young children, drunken people and the insane. In very deep burns the pleura may be implicated. The treatment of these lesions differs in no wise from that of burns and scalds in general. Cicatrization is often extreme so that extensive transplantation of skin may be necessary, the flaps coming from the arms.

Punctured and incised wounds of the thorax are largely minimized by the presence of the bony framework and hence, must often be regarded as benign in character. Like similar wounds elsewhere, they are not serious *per se* unless they chance to sever such a large blood-vessel as one of the intercostal arteries. The internal mammary artery, in these injuries, may be divided. These superficial wounds tend to heal promptly unless infected. Streptococcic infections, phlegmon and erysipelas, sometimes develop, and the pleura may be involved, especially in the latter; this from lymphatic propagation.

The division of the large bloodvessels, especially of the internal mammary, is much more commonly associated with penetrating than with non-penetrating wounds. Such wounds generally occur in complicated injuries of the thorax, and hence, these hemorrhages should be studied by themselves.

Treatment.—The treatment of superficial wounds of the thorax differs in no wise from that of similar wounds elsewhere. Suspicious wounds should not be completely sutured and those already infected should be left wholly or partly open. (For wounds of the chest, especially those due to battle casualties, see article by Dr. Dennis W. Crile, p. 313.)

Traumatic and Surgical Pneumothorax.—This is a natural consequence of any wound of the pleura. The presence of adhesions modifies the condition. It may originate from an external wound or from a rupture of the lung. It may be partial or complete. It may be unilateral or bilateral, this latter condition tending to a speedy fatality,

although intratracheal insufflation may keep the patient alive until relief is obtained. In certain cases the surgeon deliberately or accidentally opens the pleura, with a resulting pneumothorax. (Artificial pneumothorax produced by the induction of nitrogen is not considered here.)

The pneumothorax may be closed or open, closure being spontaneous or induced surgically. An open pneumothorax may be simple or valvular, air entering in the latter case but not escaping in like degree. A simple pneumothorax has a natural tendency to disappear by absorption, while in a valvular pneumothorax the intrapleural pressure has a definite tendency to increase. This latter form is known as a

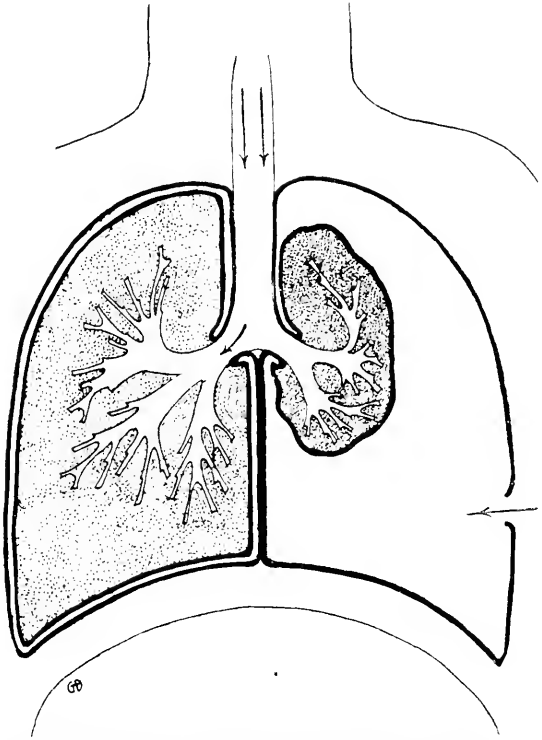


FIG. 158.—Pneumothorax from a small opening in the chest wall. Inspiration. (Anselme Schwartz, of Paris.)

tension pneumothorax. Further, in this latter type, forced expiration through reflex closure of the glottis, as the result of pleural pain, tends to increase the so-called "valvular activity," thereby causing a severe type of tension pneumothorax. Further, this latter phenomenon, following severe injuries to the chest, may lead to a rupture of the lung, and thus, in itself, be the cause of a pneumothorax.

A pneumothorax may be simple or infected, the latter form almost invariably going on to a traumatic empyema (pyopneumothorax). A given pneumothorax may, further, be of hemorrhagic or of a serous type. Whatever the form the condition is of marked importance.

The Surgical Production of Pneumothorax.—When a broad opening is made into the thoracic cavity the lung on the affected side collapses at once, generally with the production of alarming symptoms. As the air rushes in with a hissing sound the lung retracts well up to its hilum. A momentary arrest of respiration is followed by dyspnea, and this in turn is succeeded by cyanosis. Dyspnea results from atypical breathing—breathing by "fits and starts." It is accompanied by severely strained efforts on the part of all the auxiliary respiratory muscles. The pent-up CO_2 in the blood acting upon the centers in medulla causes the so-called vagus pulse; this pulse is tense,

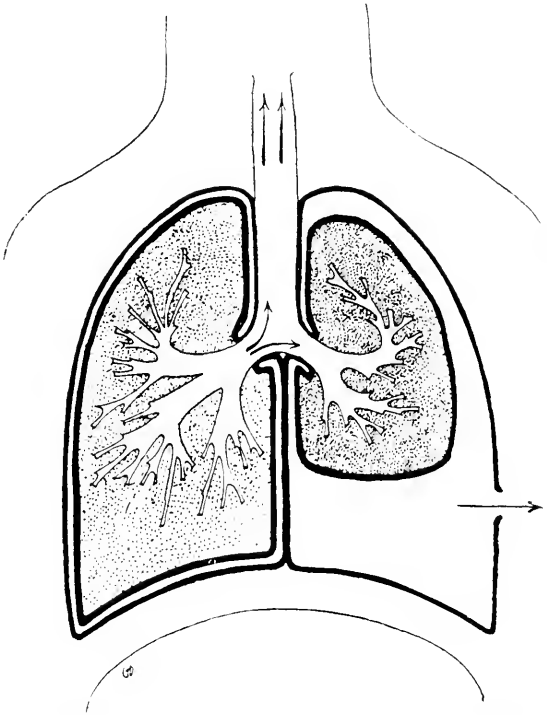


FIG. 159.—Pneumothorax from a small opening. Expiration. (Anselme Schwartz, of Paris.)

full and slow; it assorts strangely with the convulsive character of the respirations. If the condition goes on to a fatality, both the respiration and the circulation are arrested. (All of these phenomena occur very acutely in double pneumothorax.)

Provided the entrance of air is checked, that air which has reached the pleural cavity tends to undergo absorption. The entrance of a small quantity of air, as in the case of a small opening into the pleura or as in the case of a partly adherent pleura, is without harm unless infected.

When a small opening is made in the parietal pleura the air is sucked

through such an opening with each inspiration, the lung at the same time collapsing slowly. Such a phenomenon, however, does not materially interfere with respiration because the momentarily collapsed lung can still perform its functions.

The relation of a given pneumothorax to the opposite intact lung is of the greatest importance. The mediastinum is in equilibrium when the intrathoracic pressure in the two halves of the chest is the same. When pneumothorax is present to a slight degree the negative pressure on the affected side is not quite equal to that on the sound side (esti-

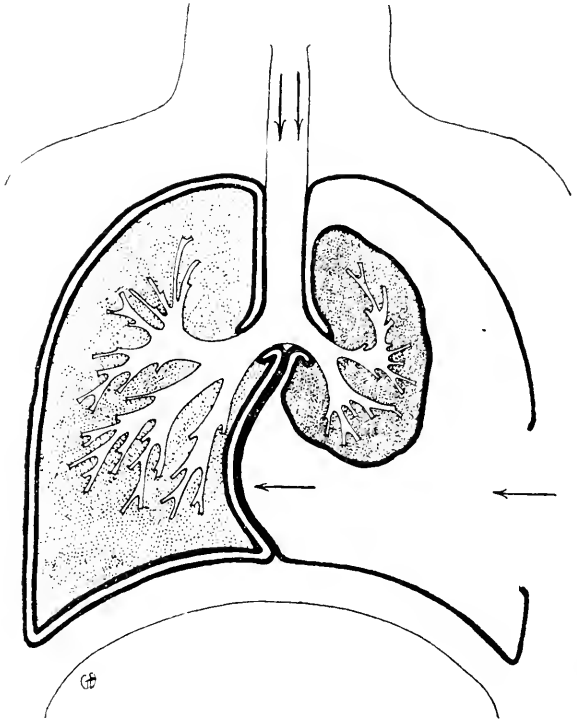


FIG. 160.—Pneumothorax from a large opening in chest wall. Inspiration. Note the curvature of mediastinum toward right lung. (Anselme Schwartz, of Paris.)

mating the latter pressure at 7 mm.). Hence, with a flexible mediastinum the sound lung must be slightly compressed. As a result of this, inspiration in the sound lung is slightly diminished while expiration (corresponding to the excursion of the mediastinum) is correspondingly increased as the intact lung pushes the mediastinum toward the side of the pneumothorax. Normal respiration, however, is not definitely disturbed in such an instance. Dyspnea is not apparent nor is there an appreciable change in the circulation.

When, however, the incision into the pleura is a large one the picture is changed. The lung on the affected side is nearly or completely elimi-

nated as air enters and escapes freely through the large pleuritic opening. Pressure on the side of the pneumothorax is that of the atmosphere while the pressure on the opposite side is 7 mm. The sound lung is more or less compressed and does not expand to the full degree. In such instance anything which interferes with expiration in the intact lung, such as forced expiration from reflex closure of the glottis, will arrest the pressure on the intact side and cause the mediastinum to project to the opposite side.

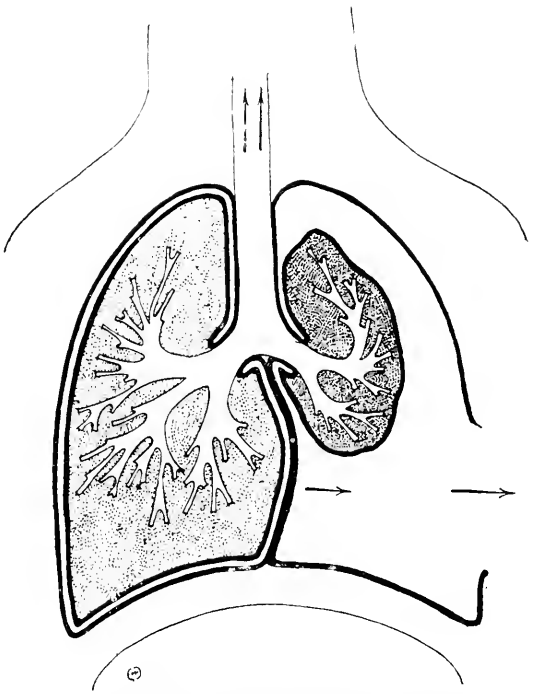


FIG. 161.—Pneumothorax from a large opening in chest wall. Expiration. (Anselme Schwartz, of Paris.)

This pendulum or shuttle action of the mediastinum tends to disarrange the respiratory activity of the intact lung, preventing complete inspiration or expiration; hence, the interchange of gases is quantitatively diminished, the body receiving too little oxygen and retaining too much carbon dioxide.

In order to increase and accelerate the absorption of air in a given case of pneumothorax, the patient may be placed squarely on the affected side. When this is done the intact lung obtains greater freedom during expiration. Further, it has been suggested that marked compression of the pneumothorax side may aid in the expulsion of air. Macewen,[1] of Glasgow, applies firm pressure with the

[1] Tr. Internat. Congress, Moscow, 1897, v, 385.

patient lying on the affected side. In such instance it is necessary to have a broad opening in the pleura. Macewen asserts that molecular cohesion will secure adhesion of the pleural surfaces. Moisture and smoothness of the contact surfaces are necessary in gaining cohesion, these tending to produce adhesions. Adhesion does not take place when the surfaces are too dry, and thus a little water or glycerin may be injected. Pathological products tend to prevent adhesions.

Quincke lays marked stress on the fact that rightsided pneumothorax is more severe than that seen on the opposite side, because the right lung is the larger and the more important.

In tension pneumothorax the air-pressure within the lung may exceed that of the atmosphere, thus tending to a displacement of the mediastinum and the heart.

Thoracico-abdominal Wounds: Diaphragmatic Hernia.—The former term is applied to wounds of the abdomen in which the thorax is traversed by the penetrating object. The diaphragm is involved and the abdominal contents may prolapse into the thorax.

Any projectile or other penetrating object which penetrates the thorax at or below the level of the ninth rib may enter the abdominal cavity. In exceptional cases the diaphragm may be penetrated from below without previous lesion of the thorax. In stab wounds of this region, the abdominal viscera not infrequently escape injury. In a large number of projectile wounds cited by Schwartz[1]—131—there was hernia of the omentum into the thorax in 37, the liver was wounded in 18, the stomach in 23 and the spleen in 20. In but 4 was there a wound of the lung.

The hernial protrusion through the diaphragmatic wound may at once undergo strangulation. The protruding part is, as a rule, the omentum. If this tissue does not undergo strangulation it gradually becomes adherent to the wound and prevents the latter from closing.

Next in frequency to the omentum, and at times associated with it, is a hernia of the intestine. Strangulation has been known to occur secondarily upon the *delayed* entrance into the wound of the omentum or intestine.

At times the extent of the external wound has been such that the diaphragmatic opening and hernial protrusion have been recognizable by the eye. The ordinary evidences of abdominal injury are generally present. Pain in the shoulder of the injured side is not uncommon. The exact lesion is often overlooked and only becomes apparent at the time of operation.

Prognosis.—The prognosis of these injuries, in the absence of intervention, is very grave; the chief cause of death being strangulation. The mortality in 70 reported cases was 85 per cent.

Treatment.—In the treatment of these injuries, operation should at once be resorted to for the purpose of liberating the strangulation, if such has occurred, and for the further purpose of suturing the wound.

[1] Chirurgie du thorax, Paris, 1912.

An exploratory operation should be performed in those cases in which hernia is suspected.

In operating, the lesion may be reached by a direct laparotomy or the transpleural route. The latter is generally preferable. There are at this time (1915) about 200 cases on record, with a mortality of about 10 per cent. It is comparatively easy to expose and suture the diaphragm by this method, reducing the hernia when present. According to Lenormant,[1] the surgical pneumothorax which follows this intervention has given but little trouble. Should an abdominal viscus be wounded, the diaphragmatic opening may be enlarged and the viscus inspected and repaired.

The operating surgeon must choose between simple thoracotomy with retraction of the ribs, and extensive resection of the ribs proper. In any case, operative procedure will prove one of the difficult surgical problems, and a supplemental laparotomy may be necessary. Suture of the diaphragm will be made according to the portion injured.

Stab wounds and bullet wounds which involve the thorax, the diaphragm, and the abdomen, always demand an exploratory laparotomy. In these cases, a most careful inspection of the abdominal contents is to be made, followed by the necessary repair of all lesions.

Traumatic Hemorrhages of the Thorax.—Internal Mammary Artery.—This branch of the subclavian divides at the level of the sixth costal cartilage into its two branches. When the parent trunk or one of its branches is severed, the division usually occurs in connection with wounds of the pleura, pericardium or mediastinum; chiefly wounds of the former. Profuse hemorrhage occurs at once. If the pleura be wounded a hemothorax generally obtains. Secondary hemorrhages of sudden, copious and very serious type may occur, if the wound becomes infected.

In securing hemostasis, it may be necessary to resect costal cartilages. Both ends of the divided vessel should be ligated, after which the wound may be completely or partially closed.

Intercostal Arteries.—These are most often injured in penetrating wounds of the pleura, and are seldom lacerated in fractures of the ribs. When active bleeding takes place from an intercostal vessel, the artery or vein should be exposed and ligated. This little procedure is a simple one; when it alone is necessary a local anesthetic may suffice. The detached periosteum at the lower border of the rib will carry the vessels with it. Resection of a contiguous portion of a given rib may at times be required. In certain instances a firm tamponade may be made; in general, exposure and ligation are preferable.

Hemorrhages from the great thoracic vessels are considered under the general subject of Cardiac Surgery.

Pleural Reflexes, Gas Embolism, Emphysema and Other Accidents due to Pleural Intervention.—Two different sets of reflex phenomena are produced by irritation of the pleura. One is seen in injuries which

[1] Bull. et mém. Soc. de chir., 1914, xl, 43.

cause pneumothorax and is described at length under that condition. The same phenomena are also seen when the pleura is much handled. In extreme cases one sees shock, dyspnea, cardiac weakness and a rapid, feeble pulse. Less marked phenomena consist in pain increased by inspiration, cough, reflex closure of the glottis and compressed breathing; the latter being due to coughing with the glottis closed. In wounds of the pleura, retraction of the lung is sometimes prevented by this mechanism.

Reflexes of the preceding character are of common occurrence and in some degree inevitable. Very different in character is another set of phenomena which occur with great infrequency, regarded as partly reflex and as in part, due to air embolism. These phenomena have been seen in connection with thoracentesis, pleurotomy, irrigation, the manipulation of drainage tubes, and, in recent years, in the operation of artificial pneumothorax. (There is no reason to believe that these differ radically from the symptoms which sometimes follow puncture of hydatid cysts of the liver: in other words, the pleura is not necessarily the starting point!)

In 1880 Riedinger[1] described these reflexes as follows: Aside from embolic processes and mere coincidences like a uremic attack, manifold and severe nervous phenomena are to be considered. These occur during incision or puncture of the pleura, and especially during irrigation of it. Simple attacks of unconsciousness belong here, these often with a fatal ending, at times with the loss of consciousness and with tonic and clonic spasms. These may occur during irrigation, perhaps weeks or months after a thoracotomy. The symptoms include pallor, slowed respiration, feeble pulse, tonic followed by clonic convulsions. There is sometimes a unilateral cyanosis accompanied by foaming at the mouth. The duration of the seizure may be several minutes. The attacks may recur speedily or at subsequent irrigations. Fatal cases have occurred. Autopsies show no constant findings. The brain may be found normal.

In a certain number of cases hemiplegia persists. Monoplegia (arm) may occur. In hemiplegia the arm is more often involved than the leg.

Change of drainage tubes has induced attacks, as have also too rapid inflow and too high tension of irrigation fluid. Pressure on the lungs, whether these are sound or diseased, or on the heart and the large vessels can cause a cerebral anemia ending in convulsions.

Leudet saw aphasia (transitory). Cerebral anemia, however produced, is a factor in these cases. Hence general anemia, cardiac weakness and pressure within the thorax alike act as determining factors.

Schwartz[2] (1912) discusses the accidents of pleurotomy as follows: Since simple incision of the pleura is the essential part of the operation, accidents should not be expected save in cases of technical blunders. In rare instances the surgeon's incision has wounded the diaphragm. The intercostal artery naturally is to be avoided. In certain cases,

[1] Deutsch. Chir., vol. xliii.
[2] Chirurgie du thorax, Paris, 1912.

pleurotomy seems to have determined secondary infection and purulent arthritis, with further secondary abscess of the brain. Most striking are the nervous phenomena described under the three heads: syncopal, convulsive and hemiplegic.

Of the syncopal form, Cestan (1898) was able to find records of but 20 cases; of this number 16 cases ended fatally. The accident followed both slight and extensive intervention as well as irrigation. The convulsive form represents a typical epilepsy with aura. The spasms may be unilateral (homolateral) or bilateral. The postconvulsive period may be that of a fatal coma: Cestan found records of 29 such cases with 13 deaths. The patients who recover are prone to suffer from vasomotor, nervous and psychic disorders. The hemiplegic form may be primary, or it may follow either of the preceding forms. These accidents have been attributed to the action of toxins, to embolism, to traumatic neurosis, etc. Zesas[1] describes these unfortunate cases as follows: Nervous phenomena are seen after pleural intervention. The reflex theory is commonly held because of negative autopsy findings. Experimentally, pleurogenic irritation may cause fatal phenomena in animals. A given reflex can be prevented or lessened if a sedative such as morphin is given. If iodin is injected into the pleural cavity, morphin being injected before, the alleged reflex is prevented and death occurs without convulsions or other nervous manifestation.

Leclerc punctured the pleura, causing an epileptiform attack. Before puncturing again he injected morphin, and, after twenty to twenty-five minutes, punctured without trouble. Zesas had a similar experience. Brauer[2] holds the theory that all of these pleurogenic phenomena are embolic in origin, beginning in the veins. The air bubble goes through the lesser circulation into the blood of the major circulation. It may lodge in an important structure—some portion of the central nervous system. Zesas states that in his opinion air embolism can hardly occur unless the lung parenchyma is injured. He is inclined to credit both hypotheses, the reflex one however, accounting for the majority of the cases.

Forlanini describes the accident of gas embolism, during the minor operation of artificial pneumothorax, as follows: When nitrogen is introduced into the pleura, it may accidentally enter the pulmonary circulation, pass into the systemic circulation and cause embolism. In most of the cases this involves the brain, especially the cortex. Such cases occurred, or should have occurred, only in the historical period of the operation, the use of a safety syringe and manometer tending to prevent such accident. (The writer has personal knowledge of one fatality, this in the practice of a very experienced physician.)

Pleural Eclampsia.—This is fortunately of rare occurrence Taking place during the operation of artificial pneumothorax, it is the same phenomenon which is encountered at times, in thoracentesis, irrigation of empyemata, the introduction of drainage tubes, etc. It may occur

[1] Centralbl. f. Chir., 1914, xli, 371.
[2] München. med. Wchnschr., 1909, No. 36.

spontaneously in acute pleurisy and can be produced experimentally in animals by introducing irritating substances into the pleural cavity. When it appears in pneumothorax operations it is generally benign (writer's experience). It occurs most often on the introduction of the needle but it may be seen at a later period (within fifteen to twenty minutes).

Forlanini, in one report, had inserted the needle in the pleura over 10,000 times and had seen but 12 cases of pleural eclampsia.

Symptoms.—The symptoms of this eclampsia are as follows: psychical (comprising confusion, with occasional loss of consciousness), and motor, consisting of diffuse tonic spasm (clonic being seldom seen) involving the upper extremity, the neck, the thorax, the eyeball and the lower extremity; these on the side of the pneumothorax. Flaccid paralysis may be seen in association with contractures, the type being mono- or hemiplegic. There is no paresis of the sphincters; the patients sometimes vomit. There are disturbances also of the pulse and respiration not seen in ordinary epilepsy; the pulse being rapid, soft, irregular, small and often imperceptible. The skin is pale with cyanotic flecks on the face, the neck and the upper parts of the chest. In a minority of cases the respiration is shallow and irregular.

A special form is that which occurs regularly at each puncture. In one recorded case, the patient passed, at each puncture, into a state of eclampsia which lasted from ten to fifteen minutes. Another patient twice developed attacks of pure idiopathic asthma.

Generally speaking, attacks of pleural eclampsia last from a few minutes to a half hour, but may be continued several hours.

This accident occurs most often in the weak and the nervous. It does not at once form a contra-indication to the slight operation, but the surgeon must exercise very great care. The blood-pressure should be taken before the prospective intervention and if it be too low a cardiac stimulant given.

Pleural eclampsia is, in all probability, of reflex, pleurogenic origin; therefore, the wound should be as slight as possible, a pointed needle being used. A local anesthetic may be employed to dull the sensibility of the pleura.

A given attack is treated by artificial respiration, rhythmic traction on the tongue, the inhalation of oxygen, massage of the heart and cardiac stimulants. Further, moderate inhalation of ether will at times arrest the pleurogenic spasms.

Lillington[1] states that many sudden deaths have occurred as a result of the induction of artificial pneumothorax. Among the causes of death, he cites pleural reflexes (including laryngeal spasm), gas embolism, aspiration pneumonia, and pneumothorax of pulmonary origin. It has been proved that gas embolism can cause death with loss of consciousness and bilateral convulsions. Enough has been said to emphasize the importance of any pleural irritation, however slight this may be.

[1] Lancet, 1913, ii, 796.

Subcutaneous and Subpleural Emphysema Occurring as a Result of Artificial Pneumothorax.—According to Forlanini, subcutaneous emphysema never occurs during the introduction of the needle but upon the extraction of it or at some time following. After the operation is completed, and as the needle is withdrawn, some of the nitrogen may pass through the puncture-canal into the subcutaneous connective tissue and there diffuse itself within the surrounding tissues. The accident is favored if the needle is large, if the tension of the pneumothorax is high and if cough is present; it is also favored by a flabbiness of the subcutaneous tissues. The emphysema appears, as a rule, close to the wound, and the gas follows the lines of least resistance, *i. e.*, where the tissue is most lax and abundant—the axilla, the subclavicular region, the base of the thorax. It may involve half of the thorax but very seldom crosses the middle line.

Subcutaneous emphysema is recognized by a characteristic (palpable), grating sound. Crepitation is heard upon auscultation and upon percussion there is a characteristic tympanitic sound of changing (usually high) pitch. If enough gas is present, the chest wall may bulge and give a doughy feeling on palpation. As time goes on, some of the gas is absorbed and crepitus may then no longer be heard during palpation; persisting, however, during auscultation. Within a few days the gas will generally have been absorbed. Massage will accelerate this absorption. The condition is entirely benign.

Deep and subpleural emphysema occurs very infrequently and at a later period than does the subcutaneous form. It is determined by a high tension in the pneumothorax plus the act of coughing. Another element, sometimes invoked to explain a given subcutaneous emphysema, is the supposed closure of the external needle wound, any escaping air which follows the needle being diverted into the loose connective tissue. Deep emphysema occurs at times when the pleural cavity is obliterated. This form appears first in the throat and the supraclavicular fossa, occasionally crossing the middle line. The patient may complain of a constriction in the throat and of difficulty in breathing and swallowing. Crepitus, both on palpation and on auscultation, may be heard, with tympanites on percussion. The gas is generally absorbed within a few days. Deep emphysema of limited extent has followed the attempt to distend a partially adherent pleura. Subpleural emphysema is of rare occurrence, aside from this type, and generally occurs in the puncture of a successful pneumothorax for the purpose of the introduction of more nitrogen.

SURGICAL DISEASES OF THE THORAX. SUPPURATIONS OF THE CHEST-WALL.

Furuncles and Carbuncles.—These tend to occur in the localities which predispose to affections of the cutaneous glands, *i. e.*, the back and shoulders. Furuncles are frequently found here and are extremely

PLATE IV

Traumatic Asphyxia. (Beach-Cobb.)

painful because of the lack of elasticity of the skin on either side of the median line.

It is said that these dorsal boils cause swelling and tenderness of the inguinal lymph nodes, although this is difficult of explanation. Henschen[1] believes in direct infection of the hair follicles by pyogenic bacteria, and states that the "mother furuncle" is always recognizable because of its greater size. The virulence of the bacilli is increased by passage. In general furunculosis, the "daughter" boils continue to disseminate the infection. Henschen mentions the likelihood of various metastases from the escape of these pyogenics into the blood, but seemingly ignores metastatic boils of the skin from internal sources.

If an aseptic major operation of any kind is carried out on a patient with a florid furuncle, infection of the blood may follow during convalescence. (Henschen cites a case of appendectomy in a "boil carrier" who fell a victim to a staphylococcus endocarditis directly after the operation. The writer has more than once encountered alarming infection in the case of a patient who was the subject of relapsing furunculosis.) A furuncle at its onset may be aborted by various simple measures, but when it has reached the second stage suitable incisions should be made directly through the necrotic center. When a certain depth is reached it gapes and a little gauze should be inserted to keep the wound open and favor the expulsion of the core. The gauze should be soaked in a mild antiseptic solution.

Carbuncles on the back may indicate such metabolic disturbances as diabetes and nephritis, the subjects, as a rule, being elderly. Occurring in younger subjects without apparent cause, the disease may be afebrile or it may present the picture of septicopyemia. Carbuncles may be regarded as boils which develop so near together as to coalesce, or as a simple boil which enlarges by concentric implication of nearby follicles.

The constitutional carbuncle is the form which carries with it a most serious prognosis, on account of the underlying metabolic disorder. This form often attains a vast size.

Treatment.—In the non-virulent carbuncle of young, robust subjects, cross-section or undermining of the lesions answers well. The incision should be made deep, and the tissue thoroughly incised. The affected fascia may be dissected out. Moist sterile dressings are appropriate and should be changed frequently. Fortunately, for cosmetic reasons, these deep furuncles are much more seen in young men than in young women, and this fact may be accounted for by the necessary recourse of the former to barbers, as well as to the wearing of stiff shirt bands, collars and the like.

In individuals who are in poor condition the entire carbuncle may be excised under local anesthesia. Diabetes is not a contra-indication. The incision is carried through the red areola down to the fascia and the mass dissected away from the latter with rapid strokes. The

[1] Bruns, Garré and Küttner, Handb. d. prakt. Chir., 1913, ii, 708.

affected fascia may be excised. Antiseptic or aseptic dressings are applied. These should be changed frequently. The severe symptoms generally subside speedily. The defect may be repaired by skin grafting.

Phlegmon of the Thoracic Wall.—Different affections may be described under this title, differing mainly in their causation. The so-called primary diffuse phlegmon is an extremely rare affection, and a review of the published cases shows that not all can be considered as primary, since they may have originated at a distance. Secondary diffuse phlegmon simply represents the burrowing of a septic abscess into the cellular tissue of the chest wall, and may include the metastatic phlegmon.

Diffuse primary phlegmon of the chest wall is in some respects a condition *sui generis*. It is extremely rare—hardly over a dozen cases having been recorded. Several French graduation theses were written on the subject between 1875 and 1882. In a few cases, the primary lesion was a wound or felon on a finger, which was followed by a suppurative adenitis of the axilla, the pus burrowing into the cellular tissue of the thorax. In other cases, the lesion followed an incision for empyema or gangrene of the lung. The germ found is generally the streptococcus. The patients have as a rule been in a poor, debilitated condition.

The usual site of the phlegmon is the anterolateral portion of the thorax, either close to the axilla or at a lower level. From the original site, the entire half of the chest may be involved, from the sternum to the spine and from the axilla to the base of the thorax. Then the edematous swelling gradually becomes purulent, and the cellular tissue necrotic. The pus makes its way slowly between bundles of muscle, some of which may undergo necrosis. In a few cases, the pus has burrowed into the throat or a secondary pleurisy has developed.

Symptoms.—The general health is markedly depreciated. Some patients have shown progressive adynamic conditions with diarrhea and vomiting. The complexion is pale and earthy, the tongue dry and fissured, and the teeth covered with sordes. The thirst is intense. The pulse is rapid (110 to 120) and the temperature may go to 40° C. The picture is, therefore, much like that of a typhoid fever. The chest is partly immobilized by pain and reflex action. The skin may be edematous and pink. At a later period, when gangrene is developing, it may be of a deep red. It may be marbled in texture and bullæ may appear. As the skin becomes involved in the necrosis these bullæ rupture and give exit to pus and gangrenous shreds of connective tissue. Erysipelas may occur in association with such a phlegmon. Nearly all of the reported cases have ended fatally.

Treatment.—If there be an initial wound it should be promptly disinfected and aseptically dressed. The phlegmon itself should be treated by multiple, deep incisions made with a bistoury or Paquelin cautery. The dressings should be changed frequently. The patient may require saline infusion and active stimulation.

Secondary diffuse phlegmon occurs more frequently than does the preceding. In the great majority of cases, it results from the extension of a suppurative process in the axilla, the throat or some other adjacent locality. Occasionally it represents a metastasis due to a general sepsis. The most common locations are the axillæ, the supraclavicular fossæ, the sternal region and the back just below the level of the scapulæ. If the virulence is not marked, a so-called "woody phlegmon" may result. (Article by the writer.[1]) The severity of the condition shows great variations. Metastatic phlegmon and phlegmon followed by sepsis, have a grave prognosis. The symptoms of pain, dyspnea, painful cough, chills and fever suggest pleuritis. Osteomyelitis must be looked for. An edematous, tender swelling indicates the development of a phlegmon. The latter phemonena of the disease resemble those of the primary phlegmon. The management must rest upon early, free incisions with thorough drainage.

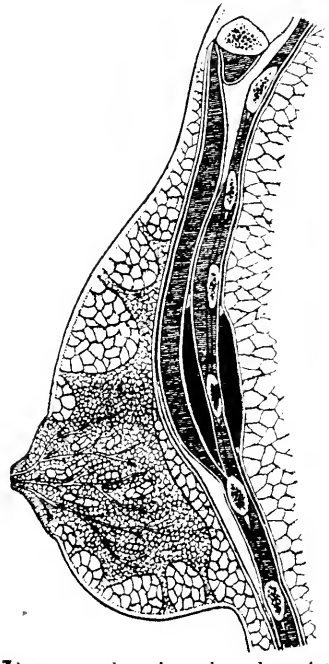


FIG. 162.—An abscess between the visceral and parietal pleuræ communicating with caries of the fourth rib. The abscess has perforated to the subpectoral space. (Anselme Schwartz, of Paris.)

Cold Abscess of the Thoracic Wall.—This tuberculous affection may originate in any portion of the thoracic wall. Originally, a cold abscess was regarded solely as proceeding from a tuberculous caries of the ribs or sternum, but later it was found to be frequently of pleural origin. In this location, it could also be spoken of as primary. A dis-

[1] Jour. Am. Med. Assn., 1911.

tinction was likewise established between an abscess due to caries and one due to a periostitis. Abscess from tuberculous granulomata of the subcutaneous tissue and from tuberculous bursitis were further isolated.

At the present day three types of cold abscess are recognized: (I) Those which originate in the bones; (II) those which originate in the pleura; (III) those which originate in the cellular tissue of the lymph nodes, the muscles and the bursæ. This last type, in comparison with

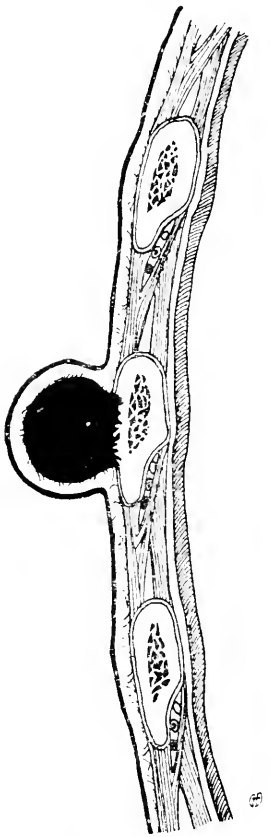


Fig. 163.—Tuberculous abscess extending outward from a rib. (Anselme Schwartz, of Paris.)

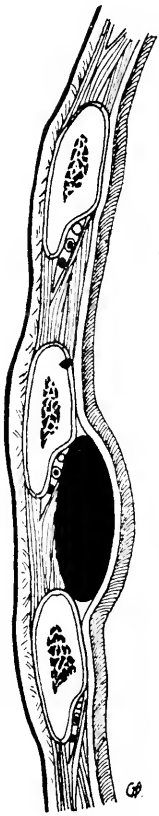


Fig. 164.—Tuberculous abscess localized between ribs and parietal pleura. (Anselme Schwartz, of Paris.)

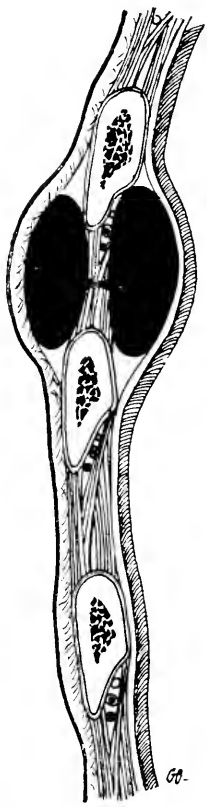


Fig. 165.—Double communicating abscess of chest wall. (Anselme Schwartz, of Paris.)

the others, is of rare occurrence. A so-called tuberculoma or tuberculous gumma develops in a given locality, it undergoes softening and discharges a seropus.

In the osteogenous form the starting point is usually a tuberculous focus in a rib. In 110 cases collected by König,[1] the starting point in each of 93 cases was a rib, in 17 cases the sternum.

[1] Arch. f. klin. Chir., 1906, lxxix, 1.

In the majority of cases, the situation was anterior (77); in 20 cases it was posterior (cold abscess of the vertebræ is not considered here) and in 13 cases it was lateral.

As a result of burrowing, the abscess may point at a considerable distance from the diseased focus in the bone.

(The writer recalls the case of a young physician who was under his care some years ago, in whom a cold abscess originating in the chest wall pointed over the right sacro-iliac articulation. The diagnosis was only made at the time of operation. Thorough operative procedure, following up the tract to the original focus, resulted in healing.)

The foci in the bone may differ greatly. There may be only a denudation of the bone, or the latter may be the seat of a circumscribed osteitis involving more or less of the thickness of the bone, which in some cases undergoes spontaneous fracture. Several adjacent ribs may at times be involved. The lesion may appear on the posterior surface of a rib in which case the abscess usually projects inward. The bacilli may first manifest their activity within a given rib and involve the periosteum secondarily. The cartilage and the osteo-cartilaginous junction may be the seat of the original process (this usually in elderly subjects). When an articulation is involved a typical osteo-arthritis develops. When the sternum is involved it is usually the body which is attacked. A sternal abscess may be superficial, deep or retrosternal. There may be much destruction of bone and spontaneous perforation is sometimes seen.

In the pleurogenous form two collections of pus are generally found; one superficial, lying outside the thoracic wall, and a deep, retrocostal collection communicating with this. This latter pocket lies between the bony wall and the parietal pleura, which latter structure is almost invariably thickened, adherent to the visceral pleura and studded with tuberculous nodules. The adjacent lung may be involved in the process. The sinus which unites the two pockets of pus may be short and direct or long and tortuous. The pleurogenous abscess occurs by preference in one of three localities, viz.: near the sternal margin in front, in the axillary line laterally and at the angles of the ribs posteriorly. The third to tenth rib space is the usual seat.

The subjects in whom tuberculous abscesses usually occur are those who, in general, are most subject to tuberculosis of the bones and lungs; children of ten or more years, adolescents and adults up to the age of forty. Abscess in a lymph node is generally secondary to a tuberculous pleurisy.

Symptoms.—When the patients are first seen they may be either in the abscess stage or a fistula may be present. The abscess generally undergoes evolution without marked local or general reaction. It is, as a rule, firm at the outset and gradually undergoes softening, when fluctuation may be obtained. The tumefaction is apt to be somewhat sensitive.

In the recognition of a sacculate pleural abscess a history and symptoms of tuberculosis of the lung, or pleura, or both will be of

value. In rare instances, the pus in the superficial cavity may be reduced into the deep-seated pocket or the cough impulse may be transmitted to the superficial collection. The main or deep-seated collection, if not evacuated, may involve the ribs and sternum secondarily; even if there is a fistulous opening in the skin, the bones may be eroded and destroyed. When the abscess originates from the anterior aspect of the bones a small, hard, immobile tumefaction may be felt; even before this has developed there usually is a sensitive area in the same locality on the rib or the sternum. If the periostitis appears on the internal surface of the ribs, the pus often burrows beneath the latter and points externally. A retrosternal abscess may burrow around the sternum or may perforate it.

A special form of cold abscess of the thorax is the so-called retromammary abscess which forms beneath the pectoralis major, chiefly as a result of tuberculosis of the pleura. The pus may infiltrate a large portion of the mamma, the cellular tissue of which is very lax.

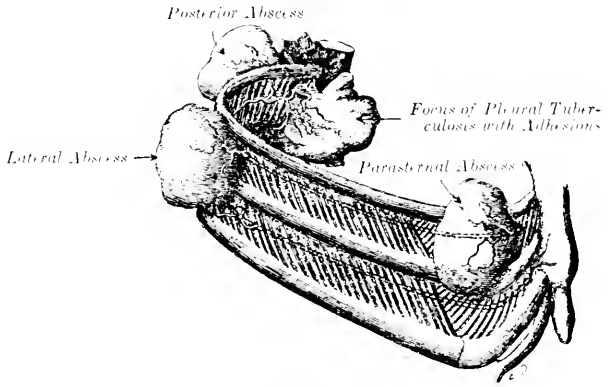


FIG. 166.—Diagram to show typical locations of abscesses arising from tuberculous pleurisy. (Anselme Schwartz, of Paris.)

Diagnosis.—In the stage of proliferation a tuberculous nodule in the cellular tissue may be confounded with a syphilitic gumma, a lipoma or malignancy. Recognition of the origin of the abscess is often very difficult. The diagnostic data have been enumerated under the symptoms.

Treatment.—Whenever possible a thorough extirpation of the focus of the disease should be made. This will generally be found to rest on the removal of diseased bone. The resulting wound together with the wall of the abscess cavity, may be mopped with pure carbolic acid followed by alcohol. The introduction of a cigarette drain or rubber drainage tube will generally be a wise measure. In isolated instances, the writer has been able to attain apparent healing by aspiration together with the injection of a formalin solution or of iodoform in glycerin; these were probably cases in which there was no diseased bone.

In certain cases, a complete removal of the wall of the abscess is to be attempted. Search should always be made for secondary pockets which can usually be located most conveniently by injecting the sinuses very slowly but very thoroughly with bismuth paste and making an *x*-ray plate which will show all the ramifications and all of the pockets. Emphasis is laid on the absolute necessity for the greatest thoroughness. Resulting tuberculous fistula may at times be cured by the use of Beck's bismuth paste.

Osteoperiosteitis of the Ribs and Sternum.—True Osteomyelitis.—This is generally of hematogenous origin but at times follows injuries. It represents a metastasis from almost any conceivable locality; the ordinary causes of suppuration being responsible. In most cases, a single rib is attacked with the costochondral junction as a favorite location. Another preferred locality is that part of the rib lying close to the spine. The affection attacks children up to ten years of age and young adults (twenty to twenty-five).

Clinically it is a severe, painful affection, appearing insidiously and without apparent cause. However, the source of the metastasis can usually be found in some primary focus: a boil, a felon, an attack of influenza or of gonorrhea. There is circumscribed swelling, tenderness, pain and painful respiration. The pus finds its way through the bone, forming a subperiosteal abscess. The periosteum is perforated sooner or later; in some cases, pus forms between the bone and the pleura, closely simulating a sacculated empyema. More frequently, the pus from the abscess escapes beneath the skin where it may burrow downward. The affected bone often undergoes necrosis, diastasis or spontaneous fracture. A fistula frequently results after evacuation of the pus. Should the osteomyelitis extend along the length of the rib the latter may undergo necrosis *en masse*.

Diagnosis.—It will be seen from the foregoing that the clinical manifestations may be manifold. Carefully made *x*-ray pictures will usually establish an accurate diagnosis.

Treatment.—Whether the bone is extensively or slightly involved, resection is indicated. A long incision is made and a sufficiently extensive resection done. This tends to remove the disease focus and to prevent fistula formation.

Typhoid Osteoperiostitis.—In this form of osteomyelitis, the cartilages are often involved to a considerable extent (osteochondritis). Typhoid fever is frequently followed by osteomyelitis and the costochondral junction is one of its localizations. It is likely to occur in the protracted and relapsing forms of typhoid fever and it is even said that its presence may at times be foreshadowed during the course of the disease. The typhoid bacillus may be present in pure culture or in association with some of the pyogenic germs, which often suppress its activity.

Typhoid osteochondritis is a much more benign affection than is the pyogenic variety. Pus formation is, as a rule, relatively slight and delayed; the bony and cartilaginous tissues appear to retain their integrity for a long period. There is often a prolonged incubation or

latent period suggesting that certain intercurrent conditions may activate the bacilli. In the pure typhoid case, the course of the disease is not unlike that of tuberculosis. The cortical bone first thickens and is then absorbed, while granulation tissue develops, with caseation at the medulla. The greater the element of pyogenics present the more the picture approximates that of pyogenic osteomyelitis, although the cartilage, even the whole of it, may be the seat of the lesion. This condition may be self-limited without sequel or may recover after discharge of the pus; healing of the fistula. In such cases, bits of dead bone or cartilage may come away.

Diagnosis.—This should rest upon certification of the typhoid bacilli, although necrosis of a rib or costocartilage, shortly after the occurrence of the typhoid fever, should strongly point to the typhoid form.

Treatment.—A very thorough surgical extirpation is indicated. Numerous cases of the condition have been under the care of the writer and he has been impressed with the necessity for a most radical extirpation. It is but proper to say that in one of the writer's cases, that of a college professor residing in a neighboring town, repeated and extensive operations were without avail and healing took place during the administration of autogenous vaccines.

Tuberculosis of the Ribs.—Tuberculous caries of the ribs causes various affections of the adjacent soft parts—(cold abscesses, fistulæ). In certain subjects apparently sound, a tuberculous rib may be the only active manifestation of a latent tuberculosis. In 70 per cent. of all patients with tuberculous rib, other tuberculous lesions coexist. The lesion is much more frequently secondary than primary; it is often derived from nearby lesions by lymphatic propagation; sometimes from remote lesions. Mediastinal tuberculous glands are believed to be a frequent source of bone infection. Injuries to the thorax sometimes result in tuberculosis of the ribs and not a few cases have originated thus among fighting troops.

These lesions comprise many pathological changes which involve the periosteum, the cortex and the medulla of the ribs, but which can be considered jointly. Spontaneous recovery is rare, for, as a rule, the tuberculous focus in the bone gives rise to local and burrowing abscesses which point in a great variety of localities (subpectoral, lumbar, abdominal, intrathoracic). Fistulous tracts are formed, and fragments of bone sometimes come away. When the tuberculous focus is first apparent, a fusiform swelling is seen and felt. This is the first stage and is due to the formation of granulation tissue. When the latter softens and forms a caseous purulent mass the second stage of abscess formation begins. The skin may or may not assume a reddish color. A soft swelling is apparent over the lesion and may be shown to contain pus. Spontaneous opening leaves a fistula.

Diagnosis.—Diagnosis during the first and second stages should easily be made; the *x*-ray gives information of a primary affection of the marrow, and puncture may show the presence of bacilli. After fistula formation, the probe may find rough bone. To map out the fistula, bismuth paste is injected and an *x*-ray picture taken.

Prognosis.—Prognosis is generally good, although cure may be difficult.

Treatment.—This should rest upon thorough extirpation of the diseased focus or foci. If a fistula be present, its tract should be well dissected out. The affected rib or ribs should be divided through sound tissue, after removing the periosteum in the usual way. Care should be taken not to injure the pleura which will generally appear to be thickened. Almost invariably, pleural preservation will be found, however, to be easy. All secondary pockets of pus are to be thoroughly evacuated, curetted and mopped with pure carbolic acid, followed by alcohol.

Abscess of the Subpleural Connective Tissue (*Peripleuritis*).—Suppuration of the cellular tissue between the chest wall and parietal pleura is practically always secondary to some inflammatory process in the tissues above or beneath it, and is, therefore, to be regarded as a complication. It is generally ushered in by a chill, by pain and respiratory embarrassment. With the progress of the affection, the pain and dyspnea increase and fever appears. Inspection may reveal a slight bulging at certain intercostal spaces, there is flatness on percussion and a lessening or absence of the vesicular murmur. When left to itself, the pus generally discharges externally after the skin has become thinned and reddened. An obstinate fistula may persist. In certain cases the pus escapes into the pleura, causing an empyema.

Diagnosis.—The diagnosis of this condition is difficult, since it is readily confounded with pleurisy, especially the encysted form. The former, as a rule, occurs at the side of the thorax and sufficiently high to permit of the recognition of a zone of lung tissue beneath which a clear percussion note and normal auscultatory sounds are found. The location of encysted pleurisy is generally lower. Peripleuritis, as a rule, runs the more rapid course.

Treatment.—This consists of thoracotomy and drainage, perhaps with the resection of a portion of one or more ribs.

Actinomycosis of the Thorax.—When this affection occurs in the chest-wall it is almost invariably secondary to actinomycosis in the lungs or in some of the contiguous areas (neck, mediastinum, vertebræ, abdominal cavity). Primary actinomycosis occurs, very rarely, in the chest-wall as a result of inoculation. Such cases are atypical.

Whatever its origin, an actinomycosis of the chest-wall closely resembles woody phlegmon; it undergoes multiple softening, cicatrization, and contraction of the thorax, which, as a result, shows considerable deformity. Occasional fistulæ are present.

In the rare instances of primary implication of the skin, the growth may be excised. In the secondary forms, all foci of softening, all fistulæ, etc., must be curetted and potassium iodide given in large doses. Lugol's solution may be used locally. The prognosis depends on the site and extent of the lesion.

Actinomycosis of the pleura is generally secondary to that of the lungs. The pleura develops adhesions, becomes thickened, and serous

or purulent exudates form. Pleural actinomycosis is a stage in the extension of the disease from the lungs to the chest-wall. Fistulæ may communicate with the pleural area, and, at times, the ray fungi will be found in the discharge.

Actinomycosis of the thorax, therefore, is primarily a pulmonary affection, which, after ravaging the lung tissue, invades the pleura and the chest wall. Like tuberculosis and cancer of the lungs, it most often originates in the bronchial tree, whence it invades the outlying parenchyma. Further, the introduction into the bronchi of various substances containing the ray fungi recalls in some degree the action of other minute foreign bodies, which, having reached the bronchioles, may set up a number of conditions as a result of the mechanical irritation; obstruction, infection, etc. (See Foreign Bodies.)

It is said that, for a time, the actinomycosis may be manifested only as a chronic catarrhal bronchitis. The process then traverses the bronchial walls and extends into the pulmonary alveoli, causing respectively peribronchitis and localized bronchopneumonia. The foci of the latter condition tend to soften and form cavities, while the peribronchitis causes extensive proliferation of the connective tissue, followed by induration and contraction. The affected area of lung tissue becomes therefore the seat of a fibrosis.

Eventually, the process reaches the pleura, causing either a dry pleurisy with adhesions, a serothorax, or both. Thence the process invades the chest-wall, as already stated. The disease, while thus moving along the lines of least resistance, still continues to extend from its original foci. It infiltrates the thorax and the pictures may then become extremely diversified.

The disease may pursue one of several courses and hence is often confused, in diagnosis, with a number of conditions, chief of which is pulmonary tuberculosis. Sputum examination is by no means decisive, for while bacillus findings may not be forthcoming, neither will the fungus be demonstrated, in a large proportion of cases. Actinomycosis seldom attacks the apex of the lung; it is most commonly found at the base. At this period the *x*-ray pictures may show a diffuse shadow in which are to be seen small dark and light areas.

When the process has extended to the pleura and the thoracic wall, an empyema may be simulated. In trial puncture for suspected empyema, the granules of actinomycosis may be brought away. If the disease undergoes softening with fistula formation the suggestion of empyema is still more pronounced. Actinomycosis of the chest-wall may readily simulate a sarcoma.

The tendency of the affection to an unlimited invasion of neighboring tissues and the lack of reliable resources to arrest its spread, makes the prognosis definitely bad although the patient may live for many years. In the earliest stages, a greater or lesser degree of surgical relief is available; at later periods the disease may be favorably influenced by drugs. Even in cases of years' standing, the lesions are sometimes operable. According to Garré, 8 cases have been cured surgically.

Cure may occur under one of two conditions: (1) the diseased focus is still confined to the lung and the surgeon proceeds exactly as in the case of any other diseased focus, by resecting the chest-wall and a portion of the lung; (2) (and this is by far the more common situation), the chest-wall is already secondarily involved; in this case, the fistulæ are slit open and all of the cavities are evacuated and curetted. Nodules of diseases are to be extirpated. The chest-wall is resected, and, if practicable, the cavities in the lung are not only opened and drained but the disease area is extirpated. In some cases, indeed in many instances, these measures must be avowedly palliative. Large doses of potassium iodide may be given as an adjuvant to surgical measures. In the experience of the editor the following plan of treatment has been most effective in these cases: Ninety grains of potassium iodide are given in half a pint of milk at 6 A.M., 2 P.M., and 10 P.M. This is immediately followed by a pint of hot water which results in the rapid absorption of the remedy without giving any gastric disturbance. The treatment is continued for four days, then interrupted for one week during which time tonics are administered; then the treatment is repeated again for four days. This plan is continued until the patient is apparently well. The administration of potassium iodide is then repeated for four days once a month for several months, in order to destroy any ray fungi which might not have been reached by the early treatment. By continuing this treatment, a number of apparently hopeless cases have recovered permanently, although the use of smaller doses of potassium iodide has previously been tried without benefit.

CYSTS AND TUMORS OF THE THORAX.

Echinococcus of the Chest.—Echinococcus cysts have been found in the subcutaneous tissues of the chest, in the ribs and the sternum, and in various muscles, notably the pectorals. A number of cases of primary echinococcus have occurred in the pleural cavity, but pleural echinococcus is usually secondary to a pulmonary lesion and due to a rupture of the cyst into the pleural cavity. Primary echinococcus of the lung is much more common than that of the chest-wall. It is not of uncommon occurrence and represents a direct infection of the lung from the intestine, being second in frequency only to echinococcus of the liver.

Echinococcus of the Chest-wall.—For location see the foregoing. The diagnosis is probably not often made in advance of treatment, although trial puncture may reveal scolices. Puncture may give the symptoms of anaphylactic shock while operative infection with the scolices is to be borne in mind. Echinococcus of the chest-wall is generally diagnosticated first as a tumor or an abscess. The hydatid thrill is seldom to be obtained.

The fluid obtained on puncture is clear and free from coloring matter or albumin; eosinophilia is present in the blood.

Treatment. If operable, the tumor should be enucleated. In other cases the sac should be cut down upon, punctured and disinfected with formalin solution or incised and drained—the last named resource, an old one, being attended with danger of infection.

Echinococcus of the Lungs. When there is intestinal infection with this parasite, the lung is a favorite seat of metastasis. In most cases a single cyst is present and the right lung is the most common seat (the left lung is said to be involved only about one-half as frequently). The cyst gradually continues to increase in size, and, until rupture or infection occurs, produces only pressure symptoms and irritation. If it compresses a bronchial tube, bronchial irritation comes on. If compressing the pleura at a given point, a localized dry pleurisy may develop. The cyst is, at times, responsible for the development of a frank pleurisy or pneumonia and this without previous rupture.

Termination in rupture occurs owing to the tendency of the cyst wall to become thinned where pressure is the greatest. Rupture is often brought on by forced inspiration (as after overexertion) or by external violence. The tissues upon which the cyst has been pressing are also thinned and vulnerable so that a cyst may rupture directly into a bronchial tube. In such a case the patient coughs up a thin fluid mixed with blood. Daughter-cells and scolices may be found in this fluid. (The writer recalls a case in which an echinococcus cyst of the liver found its way through the diaphragm and through the adherent right lung, burrowing into a bronchus through which it was discharged. The scolices were readily found in the sputum. Operation on the original cyst in the liver was followed by a complete cure.) If a cyst ruptures into the pleural sac, an acute pleural effusion is set up. After a cyst has ruptured it may close permanently, or it may refill and further rupture eventually recur.

A ruptured cyst becomes infected and undergoes suppuration. Hence, abscess or gangrene of the lung may accompany the condition. These suppurating cysts behave similarly to the sterile ones, until rupture occurs. If rupture occurs into a bronchial tube, a large quantity of pus is expectorated; if into the pleural sac, a pyothorax results.

Diagnosis.—In making a diagnosis, it is to be remembered that sputum containing scolices does not necessarily come from the lung, for a cyst in the liver may penetrate the diaphragm and discharge through a bronchus. A cyst seldom reaches the size of a man's fist before rupture, and until rupture occurs it simulates a tumor. A small cyst occurring in an upper lobe has simulated a tuberculous focus. If, with dulness on percussion, there is no disturbance of respiratory rhythm one may think of an echinococcus cyst.

Treatment.—The operative treatment closely resembles that of abscess or gangrene of the lung.

Benign Tumors of the Thorax.

The superficial growths which occur upon the thorax have little or nothing to distinguish them from those of other localities. Keloid over the sternum is perhaps the most characteristic. The nevi which occur over the thorax, the wen, fibroma molluscum, angiomata, etc., have a strong congenital and familial tendency. The bones and cartilages may be the seat of exostoses, enchondroses and acquired osteophytes. So far as is known, the pleural cavity is attacked by but one form of benign tumor, the subserous lipoma. The various connective-tissue tumors may occur in the lung but they rarely cause trouble. They are most liable to be found at autopsy.

Congenital Presternal Cyst.—This is a very rare form of neoplasm of the soft tissues of the thorax, only some 27 cases having been placed on record. The growth is situated over the manubrium, in the median line, and may be of variable size. Of 25 cases analyzed, 21 were dermoid cysts, 2 were mucoid and 2 were simple serous cysts. The mode of origin of these formations is conjectural. The most plausible view is that they are branchiogenous, analogous to the branchiogenetic cysts and fistulæ of the neck. Clinically there is an indolent mass, dating from birth, that gives a sense of fluctuation, cannot be reduced and which is not adherent above or beneath. The growths show a pronounced tendency to suppuration. They should always be thoroughly extirpated.

Malignant Tumors of the Thorax.

All portions of the thorax may be the seat of malignant growths. The skin and subcutaneous tissues are only too frequently the seat of local metastases, after operations for mammary cancer, and the sclerotic changes which they undergo, with the resulting induration, give rise to the so-called *cancer en cuirasse*. (See article on the Diseases of the Breast.) The ribs may be attacked by sarcoma, the pleura by sarcoma and endothelioma, the lungs by carcinoma and sarcoma.

Tumors of the Chest-wall.

Leaving out of consideration the secondary malignant tumors which appear in this region from direct extension or from metastasis, there remain certain primary tumors of the ribs and sternum which are malignant or semimalignant in character.

Neoplasms of the Ribs.—These begin, by preference, in the lower ribs, and tend to grow in the axis of the bones. The tumors push inward, causing pleuritic adhesions and invading the pleura and lung; while at the same time they grow outward through the soft parts, undergoing ulceration. When seated low, as is often the case, the diaphragm and liver may be involved secondarily. Metastases are the rule. Over 100 cases of these growths are on record, the majority being examples of enchondroma or sarcoma. Mixed forms of sarcoma

have been seen in a certain number of cases. In 1898 Quénu[1] collected notes of 58 cases of tumor of the ribs; about equally divided between sarcoma and enchondroma.

Symptoms.—The first symptom is pain. This pain may be local or diffused, spontaneous or induced. When seated in the lower ribs, these tumors sometimes cause pain in the shoulder of the same side. At first, the pains are intermittent and slight, later they become more constant and severe. The chest-wall is thus slightly immobilized causing a certain interference with inspiration. Fixation to the ribs serves to distinguish the neoplasms. Their size, form and consistency show all degrees of variation.

Sarcoma of the Chest-wall.—Chief emphasis is placed here upon sarcomata of the bones, as those of the superjacent soft parts are rare.

Sarcoma of the ribs may originate in the marrow or in the periosteum. The former variety soon induces a fracture of the rib and both forms grow rapidly, undergoing metastasis early. The tumors may project outward, forming a mass approximately the size of a child's head, which tends to break down and ulcerate. They may penetrate the thorax and cause the so-called "tumor pleurisy" with symptoms of pressure or irritation. Within the thorax, they produce metastases.

The sarcoma of the chest-wall occurs as a rule, in men, in the lower ribs and on the anterolateral aspect.

Treatment.—For treatment see Resection of Wall of Chest.

Enchondroma of the Chest-wall.—This semimalignant affection is not a rare lesion of the ribs; it is about one-half as frequent as sarcoma in the same locality. The growths tend to occur on the right side and to involve the lower six ribs anterolaterally. In spreading, they may pass from one rib to the next, and from the lower ribs they may invade the various viscera (liver, lungs, heart, etc.) Clinically, these are found as large, broad-based, irregular tumor-masses, which may cause no early symptoms of pressure or irritation. At times, they give rise to pressure pains through some of the local nerves. Eventually, the tumors form great round or fusiform bosses.

The course is generally extremely slow, with no tendency to heal, although ossification may take place; when this does occur, malignant degeneration appears to be prevented. The chief dangers are from internal growth, from metastases and from recurrence after intervention.

All chondromas, however innocent in appearance, should be extirpated when operable.

Malignant Tumors of the Pleura.

These may be primary or secondary, the latter being much the more frequent. Whatever their nature, they give rise to much the same symptoms. Whether originating in the pleura or invading it secondarily, a so-called "tumor-pleurisy" is set up; this is usually associated

[1] Rev. de chir., 1898, xviii, 365.

with a hemothorax. Sooner or later, therefore, there is dulness on percussion.

Fibrosarcoma and Myxosarcoma of the Pleura.—These growths are malignant and may attain very great dimensions. As a rule they show little tendency to invade nearby tissues and therefore the chief symptoms are those of pressure. Recognized at first as autopsy findings, they were brought into the domain of operative surgery by Garré who removed one successfully. (This growth weighed over 12 pounds. Originating in the pleura, it slowly enlarged until it nearly filled one-half of the thorax. In this case, dulness on percussion increased in proportion as breathing sounds diminished. The diagnosis was made by *x*-ray pictures and by exclusion. Microscopically, it was a spindle-cell sarcoma.)

Sarcoma of the Pleura.—The typical primary sarcoma of the pleura is said to be practically limited to the round-cell form. When seen early in the history of the disease, there are flattened nodules on the pleura. Recognition at this stage is extremely difficult. If the diagnosis is made during this early period, whether accidentally or otherwise, prompt extirpation of the nodules may effect a cure. The rate of growth of these initial lesions is said, however, to be extremely rapid. The growth invades the chest-wall and clinically resembles sarcoma of it. Primary sarcoma of the pleura is extremely rare, and the great majority of cases are secondary to sarcoma of the chest-wall and thus may be considered under that head. (In the writer's experience secondary sarcoma of the pleura and lung forms the most frequent complication of sarcoma of the testis. Almost all of the orchitic sarcomata which the writer has removed have later succumbed to intrathoracic metastasis.)

Endothelioma of the Pleura.—This is a malignant endothelioma originating from the endothelium of the serosa. It is said to behave more like a productive inflammation than like a tumor. Appearing, as it does, on either leaflet of the pleura the two opposed lesions may fuse and produce adhesions. The growths give rise to but few symptoms at the start, although they rapidly invade the neighboring tissues—thoracic wall, diaphragm, lung.

Secondary Carcinosis of the Pleura.—It has been seen that true carcinoma rarely attacks the pleura primarily. Secondary metastases, on the other hand, are very common.

As is usual with the other serosæ, cancerous metastases represent a carcinosis, and even at times a miliary carcinosis simulating tuberculosis.

Malignant Tumors of the Lung.

The writer believes that malignancy of the lungs is seldom recognized until the disease is well advanced. Then, certain obstructive and irritative symptoms begin; pain and oppression in the chest, with a dry cough. When marked pressure symptoms occur, dyspnea, cardiac disorders and neuralgias from nerve compression result. The lung

tends to shrink in size and retraction of the chest-wall occurs (obstruction of a bronchus may cause atelectasis of an entire lobe.) The chief physical signs are dulness on percussion and bronchial breathing. When the tumor mass breaks down, bronchopneumonia or pleurisy may develop.

Diagnosis.—Diagnosis in even the moderately advanced stages should not be difficult. Lenhartz[1] made twenty-four consecutive diagnoses. He availed himself of repeated *x*-ray and sputum examinations.

In making a diagnosis it is necessary to exclude syphilis, tuberculosis, actinomycosis and other chronic inflammatory processes, as well as leukemic tumors, mediastinal growths, aneurysms, etc.

Treatment.—The operation of resection of the chest-wall for the removal of tumors is described elsewhere. Tumors of the lung, by reason of their bronchial origin, appear to constitute a special variety of thoracic growths, which, as statistics show, are with the greatest difficulty successfully reached by such resection. It must not be forgotten, however, that the cortex of the lung may be attacked secondarily by malignant diseases of the chest-wall and pleura, and it is probable that in such cases, the future will show a constantly increasing percentage of encouraging results.

Since the introduction of the pressure-difference procedures a relatively considerable number of resections of the chest-wall have been made for the removal of pulmonary growths. Before the introduction of pressure-differences 51 interventions were recorded with 17 deaths; it is believed that under the employment of pressure-differences statistics have very materially improved. The writer is without experience here, but he firmly believes, as stated elsewhere in this article, that future results in this form of intrathoracic surgery, as in other forms, will show constantly improved statistics. He believes that surgeons in the future will be able to prolong or save life, in cases where malignant diseases of the pleura, chondroma of the chest-wall, etc., have attacked the lung.

Primary Cancer of the Lung.—Garré[2] states that he has collected notes of 130 cases of primary cancer of the lungs with but 9 operations. Only one patient survived the intervention long enough to be considered as relatively cured.

Little is known of the special causal factors. The right side is much more frequently attacked than the left, and in the vast majority of cases (90 per cent.), the disease begins in a bronchus (transition from the second to the third twigs) and, hence, in reality is a bronchial cancer. Three-fourths of all patients are males. An association with tuberculosis is more frequent than mere coincidence would seem to explain. On account of their bronchial origin, it is said that these growths, may at times, be recognized by the bronchoscope.

In the great majority of cases the new growth is not an epithelioma,

[1] München. med. Wchnschr., 1897, vol. xliv.
[2] Surgery of the Lungs, 1912, second edition.

but an adenosarcoma which arises from the submucous glands. These growths readily invade the lung parenchyma and tend to form circumscribed, uneven masses or cancerous foci. In other cases, the process creeps along the bronchi, and, in this way, infiltrates the lung parenchyma, producing a diffuse type. From a smaller or larger circumscribed mass in the hilus to the diffuse infiltration of a lobe or lobule, there are all possible gradations of size. The consistency of the individual lesions shows much dissimilarity. Some masses are as hard as cartilage while others are soft and elastic. Central softening and cavity formation may occur.

Symptoms.—The initial symptoms are those of slight bronchial obstruction and irritation, with reflected pains. If it be near the pleura, the cancer focus sets up a "tumor pleurisy." The coexistence of slight dyspnea with a bloody effusion into the pleura, suggests the diagnosis. Weakness and cachexia are significant, as in all cases of cancer.

One result of the obstruction of a bronchus is the consolidation of a considerable portion of the lung which may cause a retraction of the chest-wall. When cavities form in cancerous tissue the broken-down material may reach the sputum. Cancer cells, however, are but seldom found; the most suggestive findings being blood and large spherules of fat granules. On the other hand, the fluid obtained by the aspiration of pleural effusions may contain actual cancer tissue. In due time pressure symptoms develop in the veins of the neck and in the recurrent nerves with consequent cyanosis.

Fever, when present, is due to a toxic absorption or to actual cancerous bronchopneumonia.

Diagnosis.—The *x*-ray has rendered great service in diagnosis: three types of shadow having been described in connection with the various forms of the disease—lobar (usually upper lobe) hilus and diffuse bilateral type.

Primary Sarcoma of the Lung.—Typical sarcoma of the lung is so rare that but 30 cases are upon record (Garré). (This affection is not to be confounded with lymphosarcoma of the lung.) Ordinary sarcoma almost always occurs as a single focus, although the growth may attain a very great size. A "tumor pleurisy" is more frequent here than in carcinoma of the lung. The aspirated fluid may contain a so-called giant vacuole cell and this is said to possess considerable diagnostic value. (The writer is without experience in this.)

Unlike certain forms of cancer of the lung in which cachexia appears slowly, sarcoma of the lung invariably metastasizes early and this with early cachexia. There is as yet no successful case of the removal of a pulmonary sarcoma. Alleged examples have doubtless been sarcomas of the thoracic wall.

Primary Lymphosarcoma of the Lung.—This affection was formerly classed with the primary sarcomata of the lung, but of late years it has taken on new significance as an occupational malady, since it is known to occur with fair frequency in workers in certain mines, and as a result of the inhalation of arsenic-bearing dust. The affec-

tion is primarily one of the bronchial glands and the peribronchial tissues. Like others of the cancer types already described, it spreads along the bronchial tree, occasionally giving rise to one or more special nodules of disease, these often of considerable size.

It is thus apparent that lymphosarcoma shows more resemblance to carcinoma than to the ordinary primary sarcoma of the lung, since it is propagated along the bronchial tree and gives rise to bronchial symptoms.

Secondary Malignant Growths of the Lung.—While primary cancers and certain sarcomata (lymphosarcoma) of the lung have a bronchial origin and only exceptionally reach the pleura, it may be repeated that various malignant growths of the chest-wall and pleura can involve the lung by extension; hence, there is a continuous series of malignant tumors, primary or secondary, which involve the entire thickness of the thoracic wall, the pleura and the cortex of the lung. Not a few of these cases are examples of enchondroma. As has already been stated, the writer believes that the surgery of the future will present in this region results which are more and more encouraging.

It is not possible to place too much emphasis on the well-known fact that carcinoma of the breast is often complicated by carcinoma of the lung. A dry cough is one of the first symptoms and should always be looked upon with suspicion.

Serotherapy.—The writer has employed this widely in inoperable malignant growths and following operation for such growths. His own results have been far from encouraging.

The Use of Radium and the X-rays.—At this time (June, 1920) it may suffice to say that these measures are undergoing widespread investigation.

SURGICAL DISEASES OF THE PLEURA.

It has been stated that traumatic hemothorax causes an aseptic fever during its absorption. The surgeon regards the great majority of cases of pleurisy with effusion (serothorax) as sterile; these effusions often accompany other conditions of the lungs—as tumors and cysts—and also follow pneumothorax. The so-called rheumatic pleurisies, which are apt to be tuberculous, are doubtless sterile. A large serothorax may cause pressure symptoms in the chest demanding paracentesis, but, as a rule, the fluid portion of the effusion is absorbed, leaving the exudate behind. This exudate should be carefully watched for evidences of absorption, and puncture should be made both for diagnostic aid and for aspiration. In this way a bacterial infection may be revealed when present. A trial puncture may be made with a small syringe and suitable needle. If it be desired to evacuate the pleura, a large aspirating needle and suitable apparatus should be used. Air must not be allowed to enter the pleural cavity during the escape of the exudate.

It has long been known that the sudden change of intrathoracic pressure may be followed by syncope as a result of circulatory disturbances. When the cavity is emptied, the compressed lung suddenly

expands. To prevent too sudden changes an apparatus like that of Dieulafoy or Potain is used. In the latter, the exudate is sucked into a bottle in which there is a partial vacuum.

Purulent Pleurisy or Empyema.—These terms are generic, including infected serothorax, and cases which are purulent from the start. Sharp distinctions cannot be left to the microscope, and it is difficult to classify the various forms of the condition.

Collections of pus in the pleura may be primary or secondary. They may be large enough to cause pressure symptoms. They frequently occasion toxic absorption fever and often give rise to a rapid general septic infection. Secondary empyema is a metastasis of septic infection. Despite the character of the pus it can at times be slowly absorbed. In all untreated cases, however, the pleura becomes greatly thickened and undergoes cicatricial retraction at the expense of the lung. The pus of an empyema at times, breaks into the lung while air from the lung itself enters the pleural cavity; in this way one type of a pyopneumothorax may develop. A tension pneumothorax may follow as a further complication. In some cases of pyopneumothorax the bronchi are filled with pus with attendant danger of aspiration and suffocation. The empyema may discharge outwardly with entrance of air into the pleura. The so-called sacculated empyemata are small collections of pus encapsulated in the thickened pleura; their diagnosis is, at times, very difficult. *X*-ray pictures may be of aid.

The following rough etiological classification of empyema may be made:

Primary traumatic
Pulmonary (metapneumonic).
Mediastinal.
Metastatic.
Abdominal.

Forms of Empyema Surgically Considered.—(*a*) *Traumatic.*—There is usually an infected wound of the pleura and the effusion is generally purulent from the start because pyogenic microörganisms are transmitted directly into the pleural cavity. Since, as a result of the injury, hemothorax usually coexists, the blood plasm furnishes an excellent culture medium for germs. A pneumothorax also accompanies this in many cases and thus weakens the resistance of the pleura. In other words, the large pleural cavity is rapidly filled with a highly infected fluid. This soon begins to undergo absorption, with a resulting severe toxemia. General sepsis supervenes, icterus and other symptoms come on and the prognosis becomes grave. Prompt and thorough operative procedure is imperative. Free, dependent drainage is necessary. This should be accomplished by passing two drainage tubes at least 1 cm. in diameter entirely through the chest-wall. The portion of these tubes within the chest cavity should contain numerous small preforations. Sections of one or two ribs should be removed in the posterior axillary line while the anterior opening for the drainage tubes may consist of an incision between the costal cartilages. Frequent or constant irrigation of the cavity with normal salt solution may be wise in certain

cases, although it is to be remembered that the irrigation itself is not devoid of danger.

(*b*) *Metapneumonic*, follows pneumonia and is chiefly seen in children. The streptococcus and pneumococcus are not infrequently found in empyema. Empyema is especially common as a complication of measles and of scarlet fever. The metapneumonic type of empyema is generally benign excepting the streptococcic form. In each of the varieties a thoracotomy with rib resection is to be done as soon as possible.

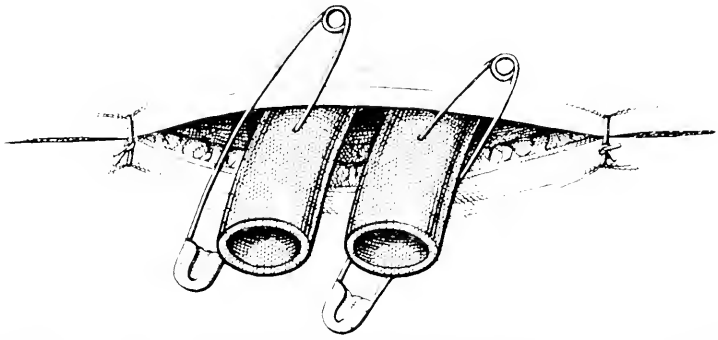


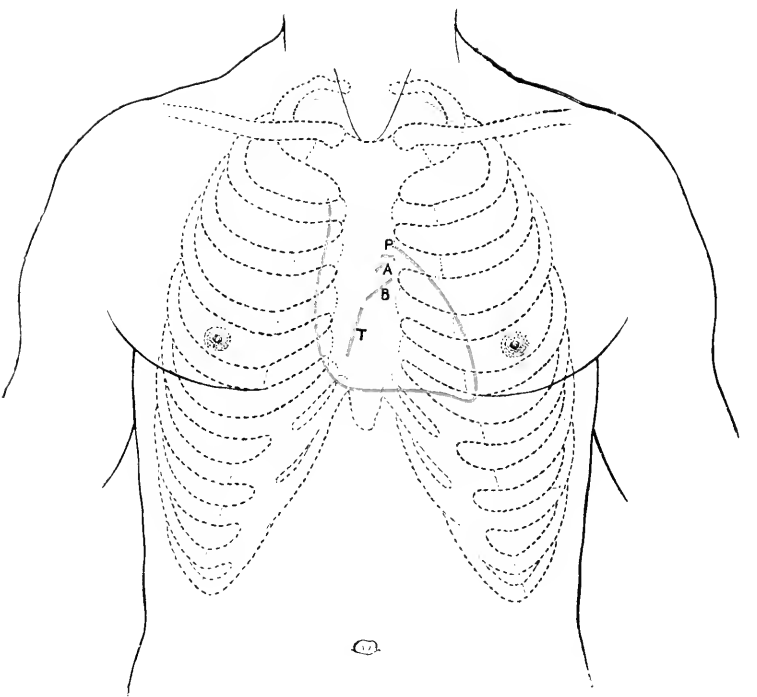
FIG. 167.—Two rubber drainage tubes extending into an empyema cavity. Safety pins to keep tubes from retracting into chest. (These tubes should be cut off short.) (Anselme Schwartz, of Paris.)

(*c*) Other types of empyema are classed together as pulmonary in origin, not including the metapneumonic form. They mainly comprise the forms caused by the rupture of abscesses, etc., into the pleura. If the pleura is adherent, it is protected in some degree. Otherwise, highly virulent, ichorous and fetid pus escapes suddenly into the pleural cavity. The condition, prognosis and treatment are those of traumatic pleurisy.

Empyemata further arise by extension from the posterior mediastinum, abdomen, etc. There is a metastatic empyema which does not originate in pulmonary lesions, but may follow influenza. This latter form is of hematogenous origin. When it complicates ordinary infectious diseases like typhoid, grippe, scarlet fever, etc., it is relatively benign, save when there is a mixed infection. When, on the other hand, it follows a surgical infection or a puerperal sepsis, it is most serious.

The tuberculous empyema may be described in this connection, although it differs from the other forms in management. Two forms of tuberculosis are to be considered. One of these is relatively mild and may appear in the course of a primary tuberculosis of the pleura, or as a complication of a localized pulmonary tuberculosis. The fluid appears to be sterile and may be left alone unless it causes pressure symptoms when it may be removed by aspiration. A thoracotomy is to be avoided when possible. (The writer is not without considerable experience in the management of tuberculous empyema and is definitely of the opinion that chest drainage is, in general, unwise. The tuber-

PLATE V



Anterior View of Thorax, Showing Surface Relations of Bones, Lungs and Heart. (Gray.)

culous pleural fistula is not apt to heal and even extensive thoracoplastic operations are often unavailing.)

Since the introduction of Beck's bismuth paste, consisting of from 10 to 30 per cent. of pure subnitrate of bismuth in yellow vaseline, many of the fistulæ resulting from the drainage of tuberculous empyemata, have healed permanently. The method of treatment consists in the injection under low, long-continued pressure of a sufficient amount of bismuth paste to fill thoroughly the cavity. At first the injection is done once a week; later once in two weeks, and still later, less frequently. If the cavity is large, a low percentage of subnitrate of bismuth should be used in order to prevent bismuth poisoning. The important point in this treatment consists in using but very little force but continuing this sufficiently long to insure the filling of all crevices with the bismuth paste. A patient may expectorate a portion of the paste for a considerable period of time, but this seems to be quite harmless. A large number of apparently hopeless cases have responded to this treatment.

A further form of tuberculous empyema is that which is secondary to caries of the vertebræ. Here, also, an empyema fistula is highly undesirable.

When a tuberculous empyema becomes infected with the streptococcus, etc., it must be treated like any other infected form, by free incision. This form is apt to leave a pleural thickening.

Surgery of Recent Empyema.—The primary indication is to evacuate the pus and supplementary to this to provide drainage for any reaccumulation (if this is foreseen) and to favor rapid closure of the cavity with as little permanent damage to the lung as possible.

It has been found that when rib resection is done while a pneumonia remains active, the mortality is much greater than when the same operation is performed after the beginning of resolution.

For this reason, as well as for the reason that adhesions will have formed tending to prevent lung collapse, it is advisable, when possible, to wait until pneumonia has passed its crisis. This holds especially for the small empyema where the patients show a "blue dyspnea," as contrasted with the cases showing a "white dyspnea"[1] where the empyema may be of larger extent and the pulmonary and general condition less alarming.

During the stage of empyema complicating active pulmonary disease it is wisest to treat the patient expectantly, drawing off the fluid through a trocar at intervals. However, if the empyema cannot be controlled by this means and the heart becomes embarrassed by pressure of the accumulation or if the accumulation reduces the available air space of the lungs (by pressure) it becomes imperative to drain. Local anesthesia must be used and quick, dextrous operation done. It does not seem that in these cases rib resection is advisable. One has the object of saving life—the question of the maintainance of drainage

[1] Leyva, L., and Legendve: The Surgical Treatment and Prognosis of Empyema following La Grippe, Surg., Gynec. and Obst., 1919, xxix, 17.

becomes secondary and the question of cavity and sinus formation is entirely eclipsed by the greater issue. Undoubtedly rib resection occasions more shock than intercostal incision and likewise the immediate postoperative mortality is greater. For this reason it seems best to do simple, quick, dextrous intercostal incision, cutting through with one sweep to the pleura and following closely the upper border of a rib so as to avoid the vessels. If the relief following tides the patient over his crisis, rib resection can be done after a few days for the production of efficient drainage. One must sacrifice ideal operating to beneficial procedures, no matter how crude or simple.

If the emergency incision is not demanded, it is wise to continue aspiration whenever sufficient fluid collects to be available. Often, if the causative organism be pneumococcus, aspiration done early and repeatedly will result in cure without open operation.[1]

It sometimes happens that the first aspiration may show the presence of bacteria while subsequent tappings are sterile. These findings definitely argue against open operation. When the reverse is true, it is advisable to do open operation whenever the organism proves to be streptococcus (which, following influenza, is very frequently found). The finding of a hemolytic streptococcus is an urgent indication for radical drainage in all conditions, as, if left undrained, this infection is very lethal. When the pneumococcus is the agent, and sometimes in the presence of staphylococcus when the reaction is slight, it is possible to thoroughly cleanse the pleural cavity of all fibrin, pus and debris and to close the chest at once. One must always attend these cases closely so that sutures can be removed at once if reaccumulation and reaction occur.

When the process is well established with thick granular or fibrinous reactions of the pleura already advanced, it is seldom possible to close the parietes. It is best to provide double drainage in these cases by making a secondary incision at the lowest point of the diaphragmatic-parietal angle, which point is most frequently in the antero-lateral aspect of the chest.

After the chest has been opened by the regular posterior, axillary seventh to ninth rib route, and after the conditions indicating most efficient drainage have been discovered, a second resection is done opposite this lowest point as determined by palpation through the first opening. Long tubes of large caliber (split) can then be drawn through from front to back and secured *at both ends* by safety pins. When hemolytic streptococcus is present it is good to provide Carrel's irrigation through a small intercostal buttonhole in the fourth or fifth space in front so that the fluid can trickle over the surfaces. When the fluid is encapsulated this is unnecessary.

Dry dressings, without valve aids, are most satisfactory. If valve aids are indicated such wounds would, in nearly all cases, have healed by primary suture of the parietes.

[1] Stone, W. J.: The Management of Postpneumonic Empyema Based upon 310 Cases, Am. Jour. Med. Sc., 1919, clviii, 1.

Thoractoomy with Rib Resection for Recent Empyema.—This intervention, upon due indication, should be performed early and rapidly

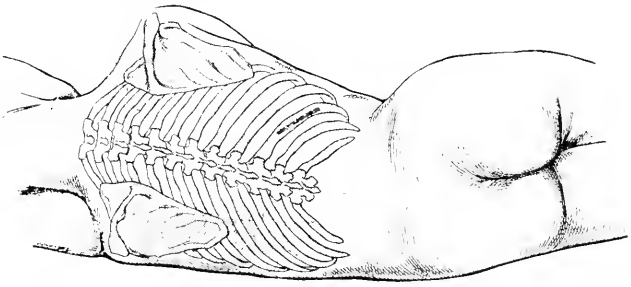


Fig. 168.—Thoracotomy. Line of incision. Usually two or three ribs are resected. (Anselme Schwartz, of Paris.)

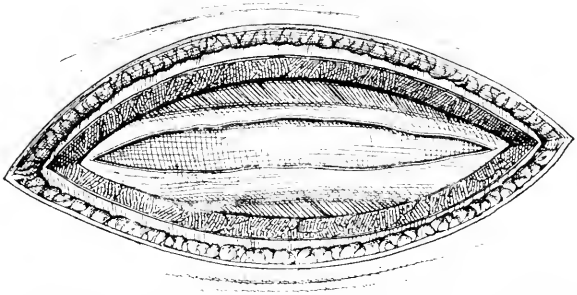


Fig. 169.—Thoracotomy. Incision through periosteum of rib. (Anselme Schwartz, of Paris.)

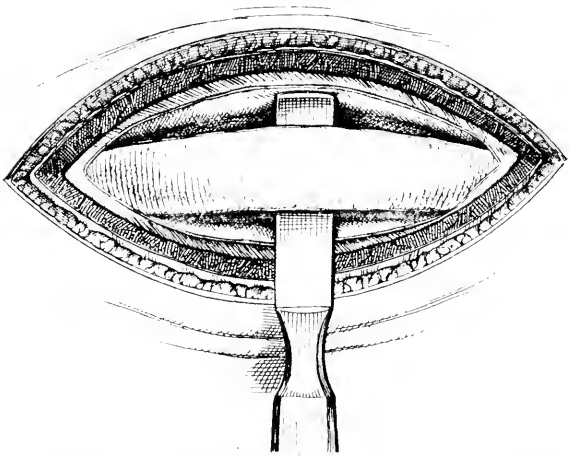


Fig. 170.—Thoracotomy. Stripping of periosteum from rib. (Anselme Schwartz, of Paris.)

under local anesthesia. The greatest care possible should be taken with the technic and incision rarely made unless the exploring needle finds

pus at the given point. The elective site is the eighth rib either in the midaxillary line, the postaxillary line, or in the scapular line, but in the

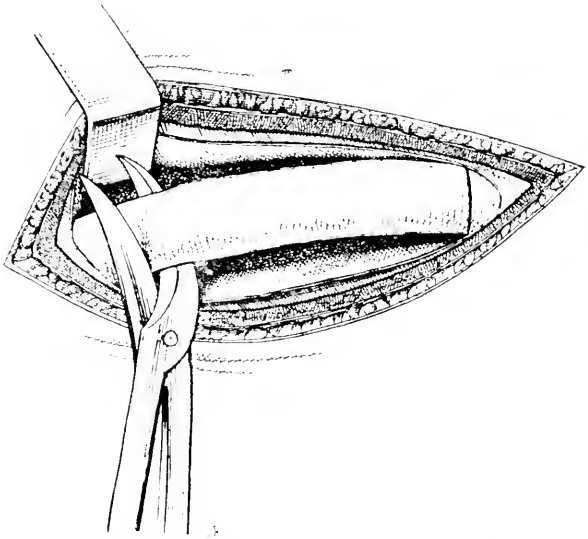


Fig. 171.—Thoracotomy. Resection of a rib. (Anselme Schwartz, of Paris)

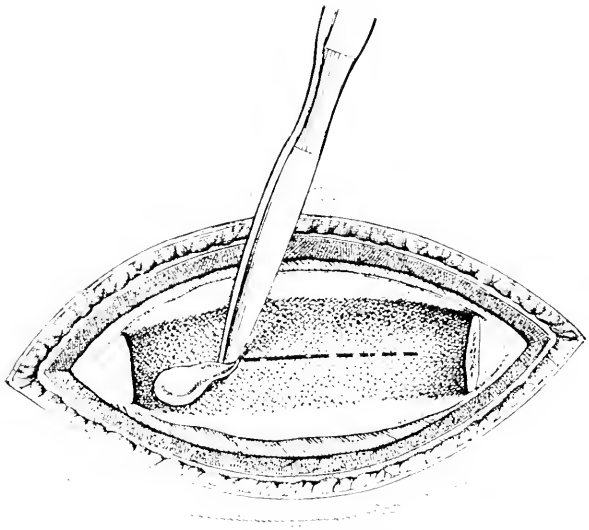


Fig. 172.—Thoracotomy. Incision of the pleura allowing the pus to escape. (Anselme Schwartz, of Paris.)

case of an encapsulated empyema the incision must be made where the pus is found. Under a suitable local anesthetic, an incision is made directly upon the given rib, the periosteum is incised and the flaps of

periosteum turned up and down. A local injection of the anesthetic is made at the lower border of the rib, into and about the intercostal nerve. The periosteum is removed from the inner surface of the rib by means of a suitable reaming instrument. If the operation be on an adult, at least two and one-half inches of the rib should be removed after double division with a suitable rib-cutting shears. During this procedure care should be taken not to open the pleura. Bleeding intercostal vessels are to be suitably ligated. A small opening is then made in the parietal pleura, and through this opening the pus is allowed to escape slowly. It tends to spurt out, as a rule, with respiration, and there is a slight pressure difference accompanying the escaping pus. The respirations then tend to become quiet, and the opening is very cautiously enlarged. If symptoms of pressure-difference seem menacing, the flow of pus is checked by suitable dressings and thus allowed to slowly escape into the dressing. When the pus has ceased flowing the gloved finger may remove fibrin and tissue shreds. Suitable drainage tubes are then put in. Irrigation of the cavity is not advisable. Aspiration drainage may be secured by the application of a so-called valve-dressing.

Too much emphasis cannot be laid on the danger of a foreign body, a drainage tube or a piece of gauze, getting lost in the thoracic cavity. There have been innumerable instances of this accident. All tubes, gauze, drains and the like, must be scrupulously secured by very large clasp-pins and in other ways (suture). All surgeons of experience have been obliged to remove from the pleural cavity foreign bodies which have slipped in after a given thoracotomy.

Sauerbruch, although he devised excellent pressure-difference procedures, does not appear to have introduced them into the surgery of empyema. However, he uses them under certain circumstances, making the usual incision when the pleura is opened. The pressure-difference used is but 2 to 3 mm.; and as the pus escapes the pressure is increased to 8, 10 and even 12 mm. It often happens that the lung is fully inflated after this escape and an effort should be made to keep it so with an approximately air-tight dressing.

Fistulæ are said to occur more commonly when pressure-differences are used.

The writer has always held a thoracotomy for empyema to be a very important surgical procedure. The drainage should be low, but it must not be forgotten in this respect that the diaphragm tends to rise after the removal of a considerable amount of pus from the pleural cavity. In many instances, the writer has passed the gloved finger into the first opening, felt the diaphragm, estimated the space and made a second opening at a point lower than that of the original incision. While the writer has fortunately avoided the opening of the peritoneal cavity in his own thoracotomies, he has known the accident to happen. Further, he has known death to follow the puncture of a large thoracic vessel during trial puncture for the pus of a small, encapsulated empyema.

A proper incision can hardly be made without the resection of one or more ribs. As the pus escapes the air tends to enter the pleura, causing a surgical pneumothorax. In acute empyema, the pleura has undergone but little pathological alteration. The pneumothorax causes collapse of the lung, and, to offset this, suction without or insufflation of air within must be used. Simple expiration, with narrowing of the glottis, partially inflates the collapsed lung and, as more air is inspired than expired, the latter should continue to expand. All this presupposes an equalization of pressure due to the open pneumothorax. If gauze is placed over the external incision the inflation of the lung will force a little air through the gauze. Not all of this air returns, and in time the valve-like action tends to bring the two pleural surfaces together, resulting in adhesions.

Placing the patient in a prone position immediately after the chest has been opened, or during the process of opening the chest, assists greatly in reducing the extent to which a pneumothorax will form, and greatly decreases the shock and discomfort of the patient. This position is also usually by far the most comfortable for a number of hours after the operations, which have just been described, have been performed. The dressing must be so applied that the valve-like principle can act continuously.

If by reason of delay the empyema has become chronic, with a residual collection of pus and dense, firm adhesions of the pleura to the lung thus crippling the play of the latter (this with the continuous formation and escape of pus), the danger of amyloidosis is great, and radical treatment is indicated.

As in the acute case, thoracotomy including resection of one or more ribs, is the operation of necessity. It has been described under other thoracotomies with resection (page 263). The writer resects the eighth rib at the scapular line.

Naturally, operation under pressure-differences solves the problem of pneumothorax. The pus is first allowed to escape with a pressure-difference of 2 or 3 mm., increasing to 8, 10 or 12. To hold the lung inflated, the external wound should be hermetically closed. The expansion of the lung is, at times, complete when the next dressing is made.

USE OF ASPIRATION DRAINAGE.

Schmerz[1] describes a plan for treating the cavity of the chest in empyema by means of a negative-pressure apparatus which was developed in the clinic of Prof. v. Hacker of the University of Graz which seems to merit especial attention from the theoretical standpoint, because mechanically the plan seems to possess many desirable qualities, and from the fact that the method has been successfully employed in this clinic in a very large number of cases. This method accomplishes the following results:

1. The pus is evacuated from the chest cavity without the introduction of air into the cavity.

[1] Zentralbl. f. Chir., January 8, 1916.

2. The chest cavity remains hermetically sealed throughout the entire course of treatment.

3. This prevents the soiling of the wound in the soft tissues throughout the course of treatment and avoids the necessity of frequent redressing of the wound.

4. There is constantly a negative pressure in the chest cavity from the very beginning of the evacuation of pus.

5. There is a rapid expansion of the lung because of the continued negative pressure which may be increased to any desired degree above the normal.

6. The patient may be out of bed immediately after the operation, provided his strength has not been too severely taxed before the operation by the long-continued existence of the empyema.

7. The period of convalescence is greatly reduced in cases in which the treatment is applicable.

Two distinct methods are described which can be applied to suitable cases.

I. *Treatment by Means of Trephining of Rib.*—1. This operation is performed under local anesthesia with novocain. A cylinder $1\frac{1}{2}$ cm. in diameter and containing all of the soft tissues down to the eighth, ninth or tenth rib is excised in the posterior axillary line or in the scapulary line, by means of a sharp narrow-bladed knife, exposing the rib as indicated in Fig. 173–*1*.

2. The periosteum is split and deflected upward and downward, exposing the rib which is perforated by means of a trephine exactly through the middle, the opening being slightly less in diameter than the rib, as shown in Fig. 173–*2*, great care being taken not to injure the periosteum on the inner surface of the rib.

3. The presence of pus is then tested by means of an exploring needle inserted through the membrane composed of periosteum and pleura on the inner surface of the rib, Fig. 173–*2*.

4. A drainage tube, slightly larger in diameter than the opening in the rib, is now stretched upon a probe as indicated in Fig. 173–*3*, in order to reduce its diameter. It is then rapidly forced into the cavity of the chest through the opening in the rib.

5. The probe is then removed, permitting the rubber tube to become restored to its normal size, which being slightly larger than the opening in the rib, causes a perfect occlusion in this opening, Fig. 173–*4*.

6. The pus is now withdrawn into a Wolff's bottle under the influence of negative pressure, the rapidity of the flow being regulated by pressure upon the rubber tube.

7. Attachment of the drainage tube (Fig. 173–*4*), with a portable vacuum bottle with negative pressure, as shown in Fig. 173–*5*.

8. The wound in the soft tissues is now tamponed with gauze about the drainage tube, which is held in place by means of rubber adhesive straps. The vacuum bottle, which is 8 cm. wide and 4 cm. in its smaller diameter, contains two necks *a* and *b*, which are inserted into rubber tubes *a* and *b*, and clamped by means of forceps *c* and *c*. A vacuum

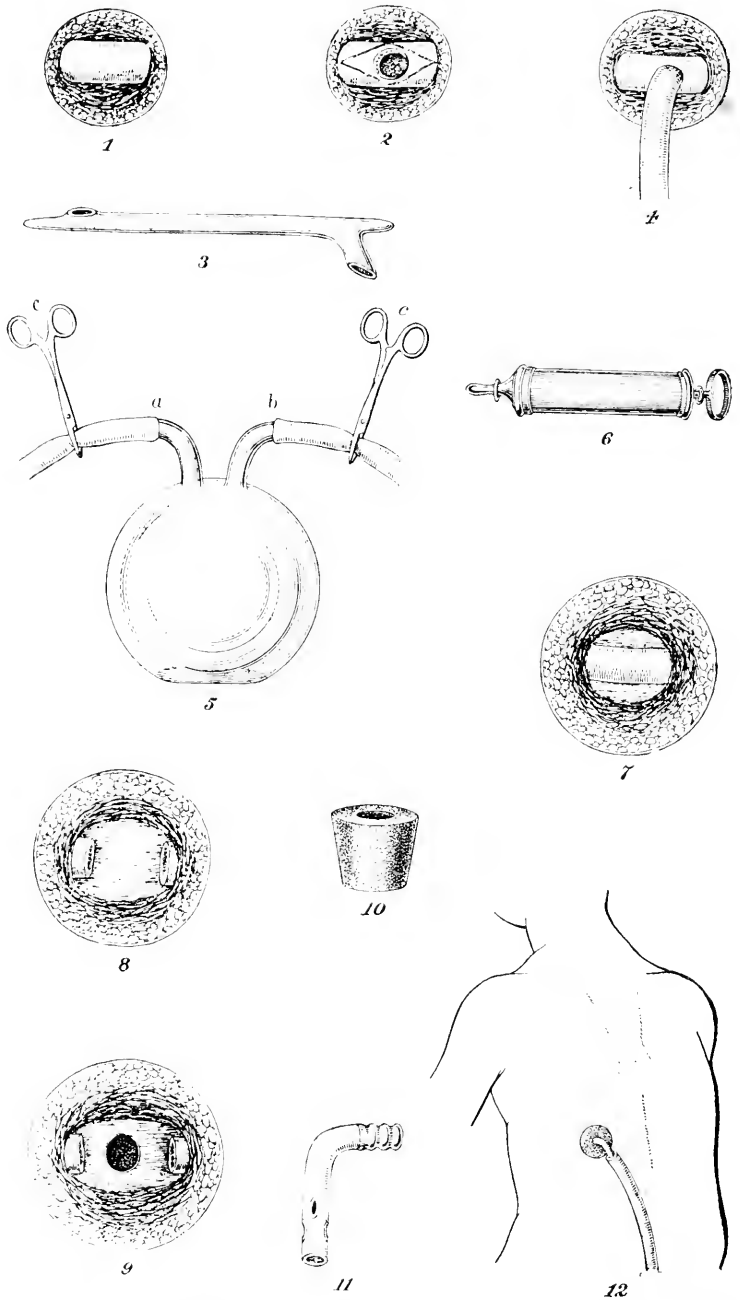


FIG. 173.—Prof. v. Hacker's method of drainage. *1*, the soft parts excised; *2*, the periosteum removed over a diamond-shaped area and a trephine hole through the rib; *3*, drainage tube stretched on probe; *4*, tube in place; *5*, vacuum bottle; *6*, pump; *7*, soft part excision; *8*, rib excision; *9*, pleural opening; *10*, cork; *11*, tube; *12*, completed drainage.

is established by means of an air-pump (Fig. 173–*6*). The drainage tube (Fig. 173–*4*), is then attached to drainage tube *a* (Fig. 173–*5*). The clamp *c* on drainage tube *a* is then removed, enabling the vacuum in the glass bottle to exhaust the pus from the chest cavity.

Negative pressure is continued in the bottle constantly by means of the air-pump (Fig. 173–*4*). The bottle is attached to the patient's clothing so that he may be about without discomfort. The method of empyting the glass bottle is self-evident.

In cases in which the pus is thin, so that it can be evacuated through an opening such as described, this method may bring ideal results.

II. *Operation Number Two.*—In cases in which the pus is too thick to be evacuated in this manner, the author recommends a second method. The method which has just been described should be tried at first, and if the pus is found too thick or if there are coagulations present which obstruct the rubber tube, then the operation can be changed to the second type, which is carried out by the following steps:

1. Again under anesthesia with novocain, a portion of soft tissue from 5 to 6 cm. in diameter in adults is excised as in Fig. 173–*7*, and in a manner to produce a conical space of the proper shape to be fully occupied by the rubber cork, as shown in Fig. 173–*10*. The space should be only just large enough so that the cork will fit very tightly.

2. A portion of the rib from 5 to 6 cm. in length is then removed after reflecting the periosteum, as shown in Fig. 173–*8*.

3. A puncture is then made to confirm the presence of pus after the cork has been forced in place tightly between the cut ends of the rib. The cork should be conical in shape and from 5 to 6 cm. in diameter in the adult, at its larger end, and from $3\frac{1}{2}$ to 4 cm. at its smaller end, while in children, at the larger end it should be 3 cm. in diameter and the smaller end 2 cm. The central opening in the cork should be from $1\frac{1}{2}$ to 2 cm. in diameter. A glass drainage tube containing lateral openings at the end which is to be introduced into the chest cavity, and corrugations at the opposite end, Fig. 173–*11*, for attaching a rubber tube, is passed through the opening in the rubber cork and attached to the Wolff's bottle as in the previous operation. The rubber cork is held in place by means of silkworm-gut sutures passed through the soft parts and over the rubber cork. It is important to place the rubber cork so that it completely fills the opening and so that it is crowded in between the ends of the rib, as shown in Fig. 173–*12*.

The remaining steps of the treatment are the same as in the previous operation, except that in order to prevent the rubber cork containing the glass tube from being forced out by means of coughing, it is fastened in place by the following method: The cork is first covered with strips of gauze, then rubber adhesive straps are placed partly around the chest and over the cork and the glass drainage tube. Other adhesive straps are passed in various directions so as to thoroughly fasten the cork in place.

The operation on old empyema residua may be done according to the

Estlander[1] or Schede[2] method, more or less modified, or through decortication. This latter has a narrower field of usefulness. The first named method, together with aspiration drainage, is given in the General Section.

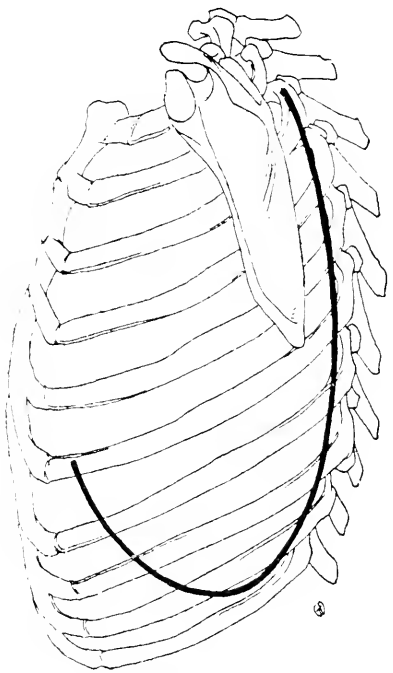


FIG. 174.—The line of incision in Max Schede's operation. (Anselme Schwartz, of Paris.)

An admirable study of empyema is that of Dowd.[3] This is based on 285 cases (all but 47 being in children) he classifies as follows:

1. Aspiration for diagnosis.
2. Methods for pus removal.
3. Treatment of chest after thoracotomy.
4. Methods of dealing with sequelæ.

Under 1 reference is made to the collection of 25 cases of death or disturbing conditions as the result of simple puncture. The danger here is greater if the opposite lung be crippled. As a rule, puncture may be made in the posterior axillary line between the eighth and ninth ribs.

2. Unless the child is very young a piece of one rib is removed under local anesthesia. The patient is asked to cough and this expands the lung. It may be necessary to detach some of the newly formed adhesions by the finger, but it is to be remembered that it is quite possible to incise below the diaphragm. (The writer has personal knowledge of such an accident.)

[1] Nord. med. Ark., 1879, xi, 1. [2] Verhandl. d. IX Congress d. inn. Medizin, 1890.
[3] New York State Med. Jour., 1914, xiv, 342.

PLATE VI

Sauerbruch's Operation for Total Thoracoplasty

3. Tubes projecting far into the chest wall are inadvisable. The author prefers Wilson's flanged rubber spool. He has never derived benefit from aspiration drainage although the receptacles may serve to collect pus. The spirometer is of great value in expanding the lung. (Wolff's bottles.) Beck's paste may prove of value in the healing of sinuses in certain cases.

4. Dowd has performed visceral pleurectomy or decortication in 19 cases. Eleven patients recovered completely while 2 others were left with small thoracic sinuses. Three others were progressing favorably at the time of the report. One patient was left with a bronchial fistula (tuberculous subject) while 2 died.

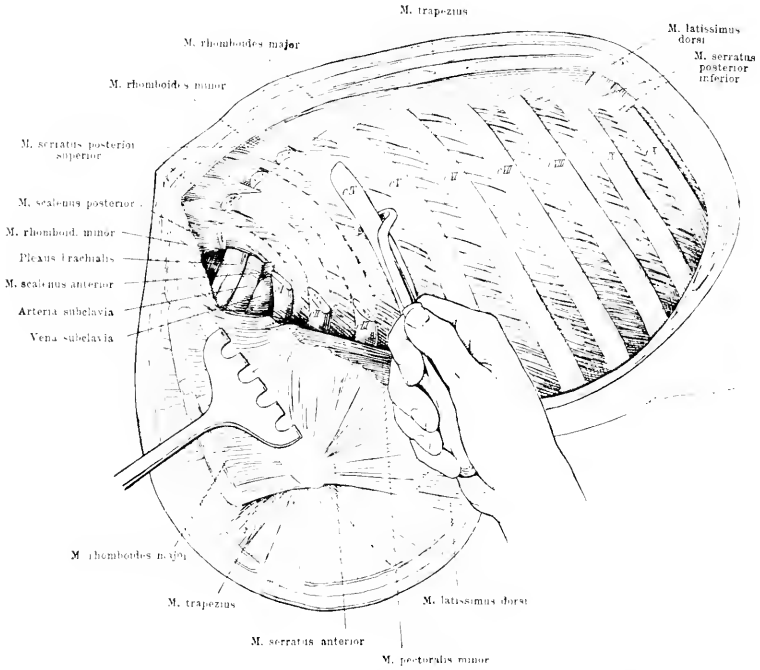


FIG. 175.—Plan of Sauerbruch's extensive resection operation.

The Technic of Extensive Resection of the Thorax in Chronic Empyema.—The modern status of the original Schede operation may be given as follows:

The operation consists of four separate acts, usually but not necessarily done in the following order:

I. A broad opening is made in the thoracic wall at the lower extremity of the empyema cavity, and the latter treated with irrigation and aseptic tamponade.

II and III. Vertical incisions are made behind and in front of the cavity.

IV. The skin and muscular flap thus formed is detached from the ribs, the bleeding vessels are ligated, the ribs, intercostal muscles and parietal pleura are divided over a suitable area, front and back, by very heavy shears. The bone flap thus formed is removed and all intercostal vessels are scrupulously ligated. The thickened pleura of the lung is criss-crossed with incisions; this pleura may be removed (decortication.) The skin and muscular flap is dropped down on the collapsed lung, pressed in place and sutured with drainage.

Operation of Decortication of the Lung or Visceral Pleurectomy (Délorme[1] and Fowler[2]).—While the Schede operation mobilizes the chest wall, thus dropping it down on the lung and obliterating the empyema cavity, decortication seeks to pare off the callous formation on the lung and thereby allow it to re-expand. The lung is exposed by a large thoracic flap. The exposed lung surface is then incised in various localities and the callosity "pried up" from the lung by blunt dissection. The lung expands and the thoracic flap now lies in apposition with it.

Sauerbruch states that there are not many *old* empyemata in which the lung can be made to expand in this manner. The procedure may well be a useful accessory to other operative measures. It is a very bloody intervention when carried out in full, and may be done only to the extent of stripping off the first layers, in connection with the Schede operation. When the operation is done on the left lung the heart at times shows notable weakness.

Despite all possible care operations on an inflamed pleura may result in very severe local or general, spreading infection.

According to Mayo and Beckman[3] (1914) this operation was then recorded in literature but twenty-four times. The intervention is said to be of little value if undertaken beyond a certain period, because the lung cannot expand. The authors, however, report one personal case in which the operation succeeded nearly four years after the original empyema; in a second case the interval was six months. Four or five months, in general, is considered the time limit. (Dowd operated on 15 of the 24 cases mentioned by Mayo.) It may be stated that the exact status of the operation is, as yet, hardly determined. The best results seem to be in cases that are operated upon fairly early, in which the given lung has not been very much compressed. (In some of these cases the lung might have expanded of itself.) It seems logical to assume that in all cases the operation must at least hasten expansion. The greatest relief seems to be desired in those extreme cases in which the lung is a firm, contracted mass held against the spinal column.

In the ordinary cases the surgeon finds that he can quite readily separate the visceral pleura from the lung, and that this separation will be followed by a greater or lesser degree of lung expansion. A primary expansion, however, may not persist and successive operations may have to be performed. Dowd seems to have quite as good results as

[1] Asso. franç. de chir., 1901, xiv, 433.
[2] Med. News, 1901, lxxviii, 933.
[3] Tr. Am. Surg. Assn., 1914.

any other surgeon. In most of his cases the sinuses closed and remained closed, the spine in a given case continued to be straight and the general health continued good. In making later examinations it is to be remembered that the breath sounds over the affected side often are misleading; they may be transmitted from the sound side.

Dowd gives the technic of decortication as follows: Under ether anesthesia, a free incision is made at the opening of the sinus and some four inches of the two adjacent ribs are resected. This gives such access to the sinuses proper that their boundaries can be fairly determined. The incision should extend to the apex of the pleural cavity. (It is important to remember this.) The incision may now be carried upward in the anterior axillary line to the third or the second rib, and the ribs and the attached pleura divided by strong shears. An inch or so is removed from the second and third ribs, 4 to 6 inches from the tenth rib, and corresponding segments from the intermediate ribs. With suitable retraction an excellent view of the sinus is thus obtained.

At this stage of the procedure the patient is allowed to so nearly emerge from the anesthesia as to permit of his spontaneous coughing, when the lung will be seen to bulge. The membrane is then separated and removed from the surface of the lung over as large an area as seems wise. (The writer thinks it proper to err on the side of quite extensive separation.) It is hardly necessary to say that the form and extent of the given operation will vary with the individual case. The chest-wall is to be fairly well pressed in and the flap of soft parts is to be suitably sutured with appropriate drainage.

(For complicating pulmonary fistula the reader is referred to the section on that subject.)

[Tuffier has had remarkable success in curing pleural fistulæ and cavities by Carrel sterilization with complete closure of the thoracic opening. In April, 1918, he exhibited a considerable number of such cases before a meeting of American army surgeons held in Paris.—C. A. P.]

SURGICAL DISEASES OF THE LUNG.

Infections (Suppurations) of the Lungs. — The lungs are often infected from the mucous membranes (and, indeed, most pulmonary suppurations have this origin), but the resulting lesions seldom possess much surgical significance since the pus finds an outlet by the mouth. An exception is found in the aspiration and impaction of foreign bodies in the bronchial rami, which are frequently very small and often may be multiple. Such may cause no symptoms, and in healthy bronchial tubes they may be carried upward by ciliary motion and expelled by coughing. If the bronchi are the seat of a catarrhal affection this conservative process is less in evidence, the foreign particles readily lodging in a small bronchial sacculation. These aspirated particles may, however, lead to infection and the infection may become putrescent. However, the percentage of suppurative foci caused by aspirated foreign bodies seems to be less than that due to bronchopneumonia and other

extensive diseases of the lungs, in which there is mixed infection. Pulmonary emboli may give rise to foci of suppuration. (Quincke fails to mention in this connection the suppurative foci which develop in the lung as a sequel to perforative wounds of the chest.)

The condition of the sputum is always to be carefully considered in estimating a given case of suppuration in the lung. When abscess or gangrene is of recent date, it is very difficult to separate the lesions. The surgeon may find it hard to distinguish in symptomatology, diagnosis and treatment between chronic abscesses of the lung and bronchiectasis, be the latter of the simple form or of the putrid form. (For the sake of simplicity foreign bodies in the lungs and the infections resulting from them will be considered together in this article.)

Pulmonary Abscess and Gangrene.—From the surgical standpoint these two conditions may be considered in common. In each case a focus of inflammation in the lung parenchyma undergoes a central softening. Pus may be present in one case, while necrotic debris are found in the other. The foci may be of almost any size, solitary or multiple; they may be encapsulated or may communicate with a bronchiole.

Gangrenous changes may come about in one of two ways: (1) ordinary pus may become infected by putrid bacteria, and (2) the sound lung may be attacked primarily by the same microörganisms. Clinically there are no hard and fast lines, for all possible transitions are seen between simple abscess formation, secondary putrid infection, and true gangrene.

Whenever, in the course of other inflammatory processes, cavities form by a softening of lung tissue the lesions are classed as abscesses —bronchopneumonia, embolism, the presence of foreign bodies, etc. Embolic abscesses may be purulent or putrid.

Foreign body abscesses are due to the impaction of various substances somewhere in the bronchial tree and gangrene may result in this way. Primary gangrene of the lung soon leads to cavity formation, the cavities being single or multiple, variable in size and often communicating.

Diagnosis.—Abscess and gangrene are generally differentiated readily by the presence or absence of gangrenous sputum. The pus may be creamy, inodorous or having a fetid and putrid smell; it may be very dark, like chocolate or prune juice. (As the latter forms are due to the admixture of blood they do not necessarily indicate the existence of gangrene.) Shreds of lung tissue with elastic fibers and pigment may be found in the sputum. In other respects, the symptoms may not differ from those present with other cavities.

In primary lung gangrene, there is an odor of carrion combined with the systemic results of putrid absorption. Naturally, these symptoms occur in the gangrenous infection of an abscess, but here they are milder or evolve more slowly.

In localization-diagnosis, the use of the *x*-ray has largely supplanted other and older methods. Various negatives from different angles should be made. It is not to be forgotten that the *x*-rays have been

misleading at times, but improvement in this important domain of surgical science is rapid and constant.

Treatment.—This is wholly surgical and differs according to the location of the disease and according to its acute or chronic character. It is advisable for the patient to attempt to empty the lung cavities by

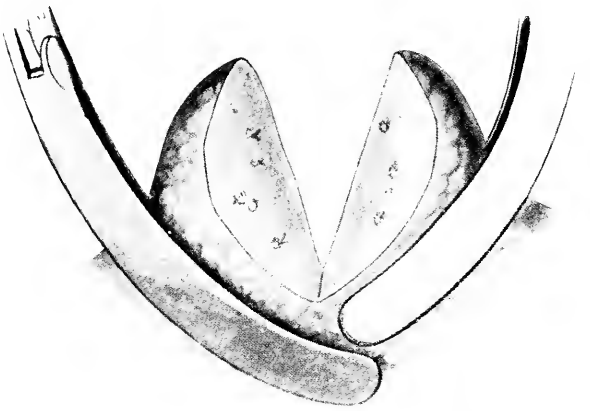
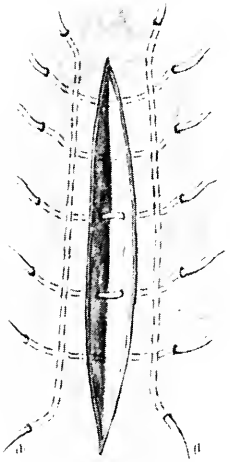
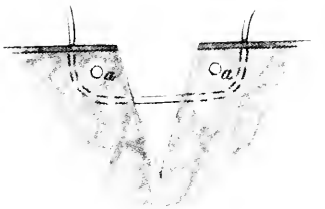


FIG. 176.—Resection of a portion of lung. Clamps applied for temporary control of hemorrhage.





FIGS. 177 and 178.—Method of suturing the lung according to Tiegel's method.

coughing before beginning a given operation. Where possible, a local anesthetic should be employed. (This may be supplanted by intratracheal insufflation anesthesia.)

A broad flap embracing three or four ribs with their intercostal spaces should be made. Adhesions are seldom present and the parietal

pleura is readily exposed. Whenever possible, the lung should be sutured to the parietal pleura to prevent collapse and to prevent the contents of the abscess cavity from soiling the general pleura.

Whether or not it be possible to suture the lung to the parietal pleura, a trial puncture with a large exploring needle is made for the location of the abscess. If pus be found, the lung is opened by the Paquelin cautery. A large drainage tube enveloped with gauze covered with rubber tissue is at once inserted and lightly tacked to the lung tissue by stitches of rather fine catgut; it should be carefully sutured to the thoracic skin, in order to prevent its displacement during the inevitable lung movements. If the abscess be of the acute form its walls generally close down fairly promptly; at times, moderately early healing will take place without resulting fistula.

The prognosis is less favorable in the chronic form of abscess. The pulmonary cavity is often unable to contract and the surgeon is obliged to mobilize the chest wall by an extensive thoracoplastic operation. (The severity of this operation is always to be borne in mind.)

Severe hemorrhages sometimes accompany the division of lung tissue, requiring a firm temporary tamponade.

Some years ago the writer was shown a most interesting case by Tuffier at the Hôpital Beaujon in Paris. For the relief of a large pulmonary abscess-cavity, Tuffier had resected several ribs without opening the parietal pleura. He then, with the hand, detached the pleura from the inner surface of the adjacent ribs and forced this detached parietal pleura firmly down on the lung. A large mass of human fat, taken from cold storage, was introduced to fill the space between the depressed parietal pleura and the thoracic wall proper. Prompt healing of the chest wound had taken place, and when the patient was seen some months after operation there was an apparent obliteration of the abscess cavity.

Chronic Simple Abscesses and Bronchiectases.—According to some authors, a chronic simple abscess readily gives rise to secondary bronchiectases because it is surrounded by a firm unyielding wall which favors the stagnation of secretion in the neighboring bronchi with consequent cylindrical dilatation. Conversely, a primary bronchiectasis, through ulceration and perforation of its wall, may set up an abscess; this is especially the case with the sacculated form. Therefore, chronic abscesses and bronchiectatic cavities are almost always found together. In theory it would be of advantage to know the number and size of the cavities in a disease focus; the precise site of the latter, and the stage of the process whether progressive or stationary—but these conditions in the ordinary clinic are difficult of realization. Cases which have thus far been submitted to operation have almost entirely been limited to the lower lobe.

Treatment.—The indications for treatment are to collapse the affected lobe, and when this is impossible to resect or amputate it. The resection of the thoracic wall must be large enough to admit of a preliminary examination for possible outlying foci. In some cases a mere decorti-

cation may enable the lobe to collapse, but should the given lobe be permeated with many small cavities and dilated bronchioles, collapse may be impossible because of the great amount of indurated tissue in it. In such a condition Quincke favors the establishment of a bronchial fistula for drainage. (This operation naturally belongs to the pneumotomies.) If none of these measures seem indicated a thoracotomy with extensive resection of the ribs, accompanied, if advisable, by decortication, may lead to the desired collapse of the affected lung.

If the pleura is not involved in the original process, and if it is not adherent, an artificial pneumothorax may be instituted.

These cases may remain under surgical treatment for weeks and months, during which time a succession of operative procedures are made until the desired collapse is attained.

Putrid Chronic Abscesses and Bronchiectases.—In many ways this condition corresponds to the preceding. Secondary foci are more prone to occur in remote areas, however, and there is a further tendency to the development of acute abscess and gangrene; these being the affections which first cause the patient to present himself for treatment. The odor of the breath and the character of the sputum are not always characteristically putrid; elastic fibers are often absent from the sputa. Absorption of putrid matter is not without influence on the general health. The subject is not as good a surgical risk as is the patient of the preceding type, but the indications are practically the same. "Collapse" surgery is probably less rational than is the direct incision with drainage and resection of the affected portion of the lung. In bilateral cases, surgical intervention would seem to be contra-indicated. (See also Bronchiectases, The Surgical Treatment of.)

Local Sclerosis of the Lung.—Aside from a generalized condition like fibroid phthisis, which is not thus far in the province of surgery, there are numerous circumscribed areas in which sclerotic portions of lung form about various lesions, notably abscesses or suppuration from any cause, bronchiectasis, pleural contraction, etc. In this manner, an entire lobe of the lung may be rendered useless. Such a form of sclerosis frequently is associated with a fistula of the lung.

In certain cases the detachment of a contracted lung from its thickened pleura may enable it to re-expand in part, or in whole.

In many cases this sclerosis is a salutary procedure and is brought about for the cure of cavities. In other cases, when a chronic abscess, bronchiectatic cavity, lung fistula, etc., continues to discharge pus, thus threatening life by amyloidosis, the entire lobe may be resected.

Foreign Bodies in the Bronchi and Lung.—These interest the surgeon from a twofold viewpoint. The larger bodies which lodge in a bronchial twig may require immediate removal, while smaller, finer particles, of many kinds, may be arrested in the bronchioles and there set up infection and suppuration. While the majority of foreign bodies reach the lung through the natural passages, others, such as bullets, fragments of shell, shreds of clothing, etc., are forced into the lung from without. These are often infected and cause suppurating foci in the lungs.

When large smooth objects are swallowed they may, if sterile, remain in a bronchial tube or twig for long periods, without causing reaction; delayed reaction, however, may supervene. In some cases the foreign bodies cause pressure-ulceration and occasion an abscess. Angular or pointed objects usually cause a prompt reaction and become immobilized, thus tending to cause obstructive symptoms.

The immediate results of the swallowing of a large foreign body are fright and pain. There is a weakening of breathing corresponding to the occluded area, as shown by physical signs. In the case of complete atelectasis or infiltration, there may be dulness on percussion. Hemoptysis is common and may be profuse if an artery is damaged; this is most likely to occur when there is ulceration or necrosis. Peculiar sounds may be heard on auscultation. Reaction symptoms show great variety—dyspnea, paroxysms of cough and suffocation, vomiting, convulsions and syncope. Bronchial irritation may be marked. In many cases there is an absence of striking symptoms.

Whenever there is even a suspicion of a foreign body in a lung, suitable *x*-ray pictures should be taken immediately. These plates will show pieces of glass, metal objects, fragments of bone, etc., but shreds of clothing, etc., are hardly ever revealed on them.

Removal by the bronchoscope is the method of choice, when such removal is possible, and the writer believes that it is not going too far to say that in bronchial foreign bodies bronchoscopy should always be attempted.[1] When bronchoscopic removal fails, thoracotomy must be carefully considered. In certain instances this may be transpleural, in other cases the extrapleural route may be employed. Bryant,[2] Schwartz[3] and others have devised extrapleural procedures, but thus far the mortality in these operations has been extremely high. With the constant development of precision in thoracic surgery the mortality will be correspondingly lowered.

Braham[4] reports the case of a pin aspirated into the left lower lobe. Operating by means of the fluorescent screen he removed portions of the fifth and sixth ribs and incised the pleura, causing an artificial pneumothorax. He extended the incision, drew out the contracted lung and removed the pin. Recovery took place.

Very different from the large type of foreign body, are the small objects, aspirated unconsciously and often in numbers, along some bronchial route. Such include a large variety of substances proceeding from the air and food passages, as well as from diseased foci in the lungs themselves. These substances, at times, immediately cause an acute aspiration pneumonia. (As a chronic, insidious process, the phthisis of knife grinders or stonecutters may be mentioned.) Certain writers regard the insidious aspiration of particles of various kinds as a definite cause of abscess and gangrene. Under this head may be enumerated certain kinds of dust, minute particles of food,

[1] The published articles by Chevalier Jackson, of Philadelphia, should be consulted.
[2] Med. News, July 28, 1900.
[3] Chirurgie du thorax, Paris, 1912.
[4] British Med. Jour., 1914, i, 1123.

including vomited matter, debris from the upper air and food passages and the like. The aspiration of such objects occurs, as a rule, during a single experience.

Normal subjects are most commonly affected while laughing, bolting food, during vomiting or while under the influence of an anesthetic. Certain abnormal subjects or states predispose to these accidents; the epileptic in his paroxysm, the subject with pharyngeal paralysis, the insane, etc.

Such aspiration is very common. The efforts of nature are often sufficient to dislodge and expel the foreign body into the larger breathing passages, whence they are coughed out.

Certain objects may be enumerated which are often accidentally aspirated and are probably, or certainly, infected at the time of aspiration; chewing tobacco, pus and debris from stomatitis, carious teeth; inflammatory products of the nasal fossæ and sinuses, the pharynx and larynx.

It is probable that such ordinary, transient aspiration seldom causes infection of the lungs unless the bronchi are already the seat of some affection (bronchitis or bronchiectasis) or unless the general condition of the patient is badly weakened by some general malady (alcoholism, diabetes).

There is evidence to show that suppurations of the lung chiefly develop in connection with lobar or lobular pneumonia; the latter apparently occasioned by the aspiration of matter infected with ordinary pyogenic bacteria. In such cases, the pneumococcus may simply stimulate into activity an older disease-focus due essentially to aspiration of infected matter. (The reader is referred to the paragraphs on Abscess of the Lung for further data.)

Pneumobronchotomy for the Removal of Foreign Bodies.—This is an operation of marked severity and one which has generally resulted fatally. Göltz, in 1907, resected four ribs and successfully removed a metal button impacted in a bronchial ramification. The case of Braham has already been mentioned. Bryant, of New York, in a paper read before the *American Surgical Association* in 1895, proposed a trapdoor resection of several ribs posteriorly. The writer had occasion to look into the status of this operation a few years after its proposal and could find no record of successful cases. In the present status of thoracic surgery a lateral thoracotomy would seem preferable.

Results of Foreign Bodies in the Lungs. Infection and Abscess.—In the type of foreign body heretofore mentioned, infected substances aspirated into the lungs may cause a series of morbid phenomena of surgical significance. In proportion as it is large and hard, the foreign body may cause an ulceration of a bronchial tube. This may lead to an abscess, perhaps even after the lapse of months. (In certain cases the symptoms may be those of an obstinate bronchitis.) Such abscess is most frequently putrid and often may lead to foci of chronic suppurations and bronchiectases, as described elsewhere. In such cases the single location, history of the aspiration of some object, and the intervening

bronchitis may point to a foreign-body suppuration. It is natural that these lesions should be central rather than peripheral. In a foreign-body abscess, the pleura is seldom involved. The favorite location, for anatomical reasons, is the left lower lobe.

FIG. 179.—Pneumobronchotomy. Position of the patient and line of incision. (Anselme Schwartz, of Paris.)

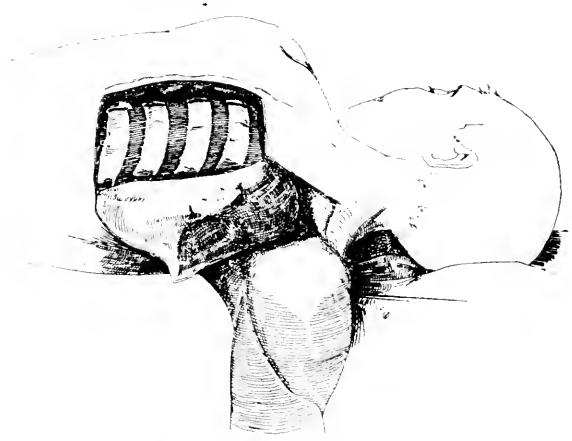


FIG. 180.—Pneumobronchotomy. Skin flap reflected. (Anselme Schwartz, of Paris.)

Schwartz's Mediastinal Bronchotomy for Foreign Bodies in Bronchi.—This operation involves opening the posterior mediastinum. The base of the flap is the margin of the scapula. The fifth to eighth ribs are divided 4 cm. from the transverse processes of the spine, and the flap turned outward. The costal pleura in the exposed region is bluntly separated outward from the vertebræ. The esophageal branch of the innominate vein and the vagus nerve are seen when the pleura and lung are drawn aside; on the left side, the thoracic aorta and vagus are

similarly exposed. The bronchus of either side can be felt by reason of its hardness. (It makes an acute angle with the vessels and nerves.) The surgeon will proceed according to indications. It is not to be forgotten that this and similar operations are procedures of necessity. In the present state of thoracic surgery, they are difficult and dangerous, but it is very probable that increasing experience will render them simpler and safer.

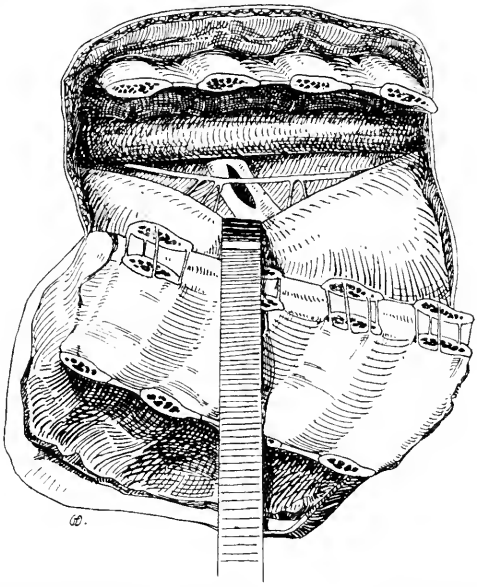


FIG. 181.—Pneumobronchotomy. An incision into the bronchus over which is seen the thoracic duct and aorta. Schwartz's operation. (Anselme Schwartz, of Paris.)

Extraction of Foreign Bodies from the Lung.—Foreign bodies can be extracted without performing an extensive operation provided the necessary equipment can be arranged. Through a small skin incision a long forceps is pushed through the substance of the lungs guided by the *x*-ray and fluoroscopic screen (the patient being supine).

The foreign body is grasped and extracted after the method set forth by Petit de la Villéon. Le Conte, of Philadelphia, has clearly described this procedure in the Tr. Am. Surg. Assn., 1919, xxxvii, 146. Le Conte's article is worthy of careful study. He concludes as follows: (1) The method is by far the easiest and most rapid way of extracting a foreign body from the lungs. (2) It is the most certain and direct way of reaching the projectile. (3) It is free from operative shock. (4) It traumatizes the least possible amount of tissue. (5) It reduces postoperative sequelæ to a minimum. (6) The recovery is rapid and the mortality low.

[In 1918 I saw this procedure carried out in France by French military surgeons, and was much impressed with its advantages; this, especially, in battle casualties.—C. A. P.]

It is often advantageous when performing the ordinary open operation to resort to the use of the fluoroscope. Some surgeons prefer to locate the foreign body accurately beforehand and to locate it by both the anatomical situation and its relation to skin markings.

It is very important that the skin markings be placed according to system so that every case will present a similar survey. It must be insisted that the patient occupy one constant position (for instance flat on his back) while both the vertical and the horizontal markings are placed on his skin. These marks will be utterly inaccurate if the patient changes his position during the marking. If his position is maintained the foreign body will be found at the point of the right angle constructed on these two points as its hypothenuse. Anatomical localizations can be made fluoroscopically. Thus a foreign body moving with the visceral pleura must be imbedded in it or the lung. Moving with the heart beat but outside the heart fixes it in connection with the great vessels or mediastinum. Such and similar facts locate it with relation to anatomical structures and this together with skin marks—intelligently applied and intelligently interpreted—make extraction easy by ordinary methods.

Hernia of the Lung.—Prolapse of a segment of a lung through the wall of the chest is known as a hernia of the lung, or a pneumocele. The congenital form which results from a defect in the thorax, is considered under malformations. The acquired form is generally the result of trauma.

Traumatic hernia may be an immediate or a consecutive matter, *i. e.*, the lung may protrude directly into a newly made wound, or only after some time has expired and as a result of a weakening of the chest-wall. In the immediate form, hernia of the lung should be regarded as a complication of penetrating wounds of the chest. The secondary cases occur in connection with imperfectly healed wounds, fragile scars, poorly united fractures of the ribs, etc. Similar to these latter are the acquired cases due to some disease process which weakens the chest-wall (suppuration, muscular atrophy). There are certain other cases in which the etiology is quite obscure.

In the production of a hernia, there must be sufficient force or pressure exerted from within, to expel the given segment of lung through the breach; such a factor is, at times, found in a severe cough. In many cases an evidently provocative factor is often absent.

In a miscellaneous collection of 41 cases of pneumocele,[1] 17 occurred in children; of this number 10 were congenital. There were 3 cases in women and 21 in men.

Hernia without trauma, sometimes wrongly termed spontaneous hernia, may occur in various localities, but is most commonly seen in the anterolateral region at the fifth and sixth intercostal space. This appears to be the locality of least resistance. (Hernia in the supraclavicular region was seen 9 times in 41 cases.) The size of the hernia varies with the weakened area of the chest-wall. If the hernia

[1] Débienne: Thèse de Paris, 1897.

be at the site of a small wound, it may be correspondingly small and simply break through an intercostal muscle. The skin may be normal or it may be the seat of a scar. The cellular tissue may be normal, or, if the hernia be due to an unhealed wound, it may be infiltrated with coagulated blood or air (emphysema).

The thorax proper—osteomuscular layer—may be the seat of fractures, rupture of muscles, pus formation, muscular atrophy or some congenital defect which serves to weaken the chest-wall. The pleura, especially in cases which develop gradually, may be likened to a hernial sac. The prolapsed lung may be apparently normal or it may be the site of a suppurating tuberculous or other process; it may or may not be adherent to the parietal pleura.

Hernia due to trauma is the more common form and in the great majority of cases the lung tissue is apparently normal. The wound is apt to be close to the free border of the lung in order for it to escape into the wound. As a rule, the hernia occurs just where the wound is made. Pneumothorax, however, is not apt to form, the lung acting as an obturator. Theoretically, the hernia occurs when the intrathoracic pressure is suddenly elevated, as by a pleural reflex closing the glottis together accompanied by violent coughing. The prolapsed lung is always distended with air and soon becomes congested and edematous in its new location; this tends to incarceration. Unless replaced at once, adhesions form and fix the lung in the wound. Then it gradually undergoes atrophy, dessicates and is apt to come away, with or without the production of a fistula. A fistula generally means that a bronchial tube of a certain size was present in the hernial mass.

The congenital form of pulmonary hernia, associated with defects in the chest wall, is apparent at birth. The traumatic form usually appears abruptly, while the spontaneous form is apt to come on gradually. Should it occur abruptly there may be a sensation of laceration and violent pain, perhaps syncope. When a hernia has occurred, the subjective sensations are, as a rule, ill-defined. There is a traction on and a compression of the lung segment, which may or may not give rise to pain and oppression; these latter symptoms appear to be due to a passive congestion. In several cases attempts at reduction of the hernia have been attended with nausea and suffocative feelings.

Palpation usually gives the sensation of a soft, spongy mass, but, at times, the prolapsed lung is firm to the touch. The diagnostic evidence of lung tissue lies in the characteristic feeling of crepitus, but it is to be remembered that this cannot always be obtained and that crepitus may be that of a localized emphysema. (In the majority of recent cases reduction is readily effected.) In a segment of considerable size the usual auscultation and percussion phenomena may be elicited. A paradoxical type of respiration is sometimes seen, *i. e.*, the lung segment becomes smaller on inspiration and larger on expiration. Coughing generally causes the tumor to protrude, often with characteristic sounds.

Pneumocele has been confounded with cold abscess, tumors (angiomata) and hernia of the muscles, emphysema of the chest-wall, etc.

Treatment.—*Traumatic Hernia.*—If the lung segment is reducible, the hernia and sac and adjacent tissues should be carefully cleansed, the lung replaced, and the wound sutured. If the herniated portion is irreducible and has undergone tissue changes, it should be resected. After resection the pedicle should be replaced within the thorax. Before resection the lung should be drawn out until a healthy portion protrudes; the ligatures are to be passed through sound tissue. Ligation of prolapsed tissue proper has resulted in infection.

Spontaneous Hernia.—If reduction can be effected the hernia may be snugly strapped in the hope that it will not recur. If it be irreducible or very painful (following violence), the overlying tissues should be widely incised, the hernia reduced, the sac (pleura) resected and the opening sutured most carefully. In spontaneous hernia it is seldom necessary to resect the lung.

In severe cases of lung hernia it may be necessary to do plastic operations involving bone mobilization or transplantation, etc.

Pulmonary Fistulæ (*Exclusive of Pleural Fistulæ*).—These chiefly result from operations, or from the spontaneous discharge outward of some suppurative process within the thorax; to a lesser extent they follow penetrating wounds. A special type is that of the bronchial fistula in which there is a free communication between a bronchus and the surface of the chest. Practically all of the surgical diseases and suppurative infections processes in the lungs have, at times, caused fistulæ. (It is to be remembered that a fistula in the thoracic region does not necessarily proceed from the lung or the pleura.)

Fistulæ of the lung are of a twofold type. They may be narrow, long, irregular in course, with recesses. These tracts discharge pus, but air does not escape from them. At the other extreme are fistulæ, comparatively rectilinear, which communicate directly with a bronchus or with a lung cavity. In this form, air enters the tract with each inspiration and is expelled during expiration. Garré calls attention to the peculiar noises produced by coughing, these noises resembling those heard in tracheal fistulæ. Violent efforts at coughing may induce subcutaneous emphysema at the external opening of the fistula. These fistulæ tend to follow the presence of a cavity or a defect in the lung tissue which cannot be repaired; they likewise tend to occur when spontaneous closure is prevented by the contracting cicatricial tissue of the diseased structures.

In discharging fistulæ (these are due as a rule to a communication with an abscess cavity), there may be a distinct indication for surgical treatment. If there is no probability that the original focus can be extirpated the fistula should be left alone when it seems useful for purposes of drainage.

Radical operation, in these fistulæ, consists of a suitable resection of the thoracic wall and an extirpation of the diseased focus. Primary, complete suture can rarely be made.

For the cure of a pulmonary fistula which does not greatly trouble the subject—save for the cold air which enters the bronchial tree without warning and thus provokes coughing—the various tissues

originally injured are to be mobilized, the edges of the fistulous tract freshened, and an attempt made to close it. Garré mentions one case in which he sutured the end of the fistula to the thickened pleura which could later be loosened by decortication. He warns against too much rib resection, in a young subject, which may cause great retraction of the thorax and consequent scoliosis. Garré, however, does not discourage the use of simple measures for the cure of small fistulæ, for these can sometimes be cured without the severe operative interventions. If the canal can be closed by cauterization, etc., the external orifice may be covered by plastic work.

Diagnosis.—In diagnosis caution is made against the probing of deep fistulæ, lest severe suffocative coughing spasms be set up. A lung fistula may be distinguished from an unhealed empyema by the respiration test.

The Use of Beck's Bismuth Paste in the Treatment of Old Empyemata, Pleural, Pulmonary and Other Fistulæ.—This is often useful, but a warning should be given as to the dangers attending the introduction of too much bismuth into the thoracic cavity. The writer recalls the case of a young man who presented himself with profound bismuth poisoning: a greatly swollen, blackish tongue, swollen, blackish mucous membranes of the mouth, profuse, fetid discharge, fetid breath, great prostration, very rapid pulse, etc. Relief slowly followed the operative removal of a very considerable amount of bismuth paste from the pleural cavity. A subsequent thoracoplastic operation resulted in permanent healing. (See special article on the use of Beck's Bismuth Paste in Vol. IV.)

Bronchiectasis.—This affection may be divided into a primary or diffuse form, and a secondary or more circumscribed type. It is not necessarily implied that the former represents the medical, and the latter the surgical phase of the disease, for large cavities may be produced in both; but the primary type may be regarded as the sequel of a chronic bronchitis or asthma, while the latter arises from the operation of local causes.

The primary form is generally held to be due to two main factors: The first, or predisposing factor, is a weakening of the bronchial wall from any cause whatever, while the exciting cause is chiefly an elevation of air-pressure in the bronchial tree due to paroxysmal and protracted coughing with partial closure of the glottis; a combination which is responsible, in part, for a number of other pulmonary affections, such as rupture of the lung with pneumothorax and interstitial emphysema, tension pneumothorax, alveolar emphysema, etc.

The weakening of the bronchial wall is the natural result of chronic bronchitis or of asthma, but it is asserted that the given bronchitis is not a mere catarrhal inflammation but an infected one in which virulent microörganisms are present. Hence, the penetration of the bronchial wall by the latter, is responsible for a peribronchitis as well. The effects of increased pressure upon this softened wall ordinarily consist of the production of certain cylindrical dilatations of the smaller bronchial twigs. In other cases narrow dilatations give rise to sacculations; sometimes a series of these sacculations giving the

tube a varicose appearance. The precise development of bronchiectases is not well understood. Thus, contrary to the general rule of a weakening of the tube wall as a result of the infection, there sometimes occurs a peribronchial hypertrophy which leads to induration and to stenosis of a bronchial twig. Thereupon, a dilatation forms distally to this constriction. Another point not readily understood, is the alteration which takes place in a bronchiectasis. Retrograde changes from lack of function do not appear, for, although the mucosa is destroyed, it is replaced by a tissue suggesting an abscess wall, which tissue produces pus in abundance. The peribronchial tissue is also the seat of a productive inflammation, and the resulting new connective tissue undergoes cicatricial contraction; thus, there is presented a section of lung in which the infective cavities lie in the midst of indurated, fibrotic lung tissue, the whole being functionally useless and a menace to the general health. While a putrid bronchitis may occur without bronchiectases, the pus which stagnates in the latter quickly takes on a putrescent odor; there is a certain amount of toxic absorption, and, as under similar conditions, amyloidosis may develop.

In considering localized and circumscribed foci of bronchiectasis, physicians ascribe the great majority of them to pneumonia and pleurisy. In the case of the former the affected lobe or lobules do not end in resolution, but a fibrosis and contraction develop so that the bronchioles undergo stenosis, dilatations and other changes. The pleuritic type may be a complication of the pneumonic, and if this occurs the lung cannot retract; thus, the bronchial twigs and bronchioles that are affected become straightened out between the two forces into long, straight cylinders. In certain cases of diffuse bronchiectasis, pleurisy may be secondarily set up, with the same ultimate result.

Circumscribed foci of bronchiectasis may occur in any condition in which there is a localized fibrosis of the lung, *i. e.*, after bronchial obstruction and atelectasis, retraction of the chest-wall, or prolonged compression by a pleural exudate.

Since surgeons are likely to see bronchiectases only in advanced cases with complications, the reader is referred to the account of the clinical condition in which bronchiectases and abscesses are closely associated, in the article on Abscesses of the Lung, page 274.

But a very small fraction of cases can hope for benefit from surgery. Many internists go so far as to deny that surgical intervention, which is solely for the purpose of giving relief, is at all indicated, even in the circumscribed type.

Diagnosis.—Diagnosis is very difficult because the patient may have only a chronic bronchitis. Before the period of bacteriological research, old subjects with chronic bronchiectases were often looked upon as tuberculous; even to lay tuberculosis must be strictly excluded. While bronchiectasis is often associated in its late stages with abscess and gangrene, it may frequently simulate those conditions when they are not present. A case must be watched for a time before a definite diagnosis is made, and the *x*-ray is often of value when cavities are present.

Untreated bronchiectasis seldom kills outright, but so many dangerous complications arise, that death may occur in a variety of ways, both general and local. Under the former are comprised various results of toxin absorption, expressed as rheumatoid and even septic conditions; metastatic abscesses may also develop. Amyloidosis and degeneration of the myocardium are not uncommon sequelæ. General weakness and cachexia develop in due time.

Very menacing local symptoms may be in evidence, such as gangrene with profuse hemorrhage, or rupture of a cavity into the pleura with the development of a threatening type of empyema. Cancer has developed in a bronchiectatic lung.

All of these conditions tend to prevent serious thought of surgical intervention save when special circumstances are present. The lower lobe being the favorite seat of large cavities, however, suggests thought of operative measures. In the treatment of chronic empyema, the secondary bronchiectases are sometimes cured by suitable management of the primary condition. Simple opening and drainage of pulmonary cavities is hardly to be considered seriously. If, on the other hand, there is a circumscribed focus of bronchiectasis (several cavities coexisting in a contracted, fibrotic section of a lung) pneumectomy or lobectomy may be of value in prolonging life, while the various forms of cavitary or "collapse" surgical-therapy may be applicable, as is the case in tuberculous cavities.

Surgical Management.—A bronchiectatic cavity is most difficult of management. Pneumotomy with drainage is indicated in theory, applying the technic of operations on chronic pulmonary abscesses (a two-stage intervention being preferable.) The first stage would comprise some form of resection of the thoracic wall, and if dense pleural adhesions are encountered, it may be possible to finish the operation in this one stage by opening the cavity through the adherent lung. If no adhesions are present, the lung can be drawn out of the resection opening and the cavity, located by palpation, opened and packed with gauze. (See Abscess of Lung, page 274.) Pleural adhesions are seldom absent. In these cases a pulmonary fistula generally persists.

In cases without adhesions, the operation may be done under pressure-differences (insufflation); the pleura must be walled off, the cavity located, drained and sutured, and the lung anchored to prevent its collapse. Artificial adhesions are set up by gauze mull or some other mild irritant.

If there are several cavities in a single lung, "collapse" therapy is apparently indicated, but it has not thus far given satisfactory results. If there is evidence that the chief cause of the cavities is pleural adhesions, mobilization of the chest-wall is indicated; a thoracoplasty to effect a collapse. Should the walls of the cavities be unusually thick or rigid, collapse cannot occur, although the operation may give a measure of relief.

A resource similar to that of the "collapse" therapy is ligation of the pulmonary artery, causing an atrophy of the lung. This should be done

at a relatively early period. The operation, like so many others in thoracic surgery, is in a formative stage.

Pneumotomy and collapse treatment are only adapted to certain cases of bronchiectasis. In advanced cases of multiple cavities where none of the methods already mentioned hold out hope, the entire lung may be mobilized by an extensive resection of the ribs, detachment of the adherent lobes of the lung, and suture of the lower margin of the latter to the diaphragm. The complemental space should be tamponed and the lobe allowed to atrophy.

Resection of a lobe containing a cavity may be thought of. (See General Technic of Lobectomy and Pneumectomy.)

Emphysema of the Lungs.[1]—Typical emphysema, otherwise known as the large-lunged form of emphysema, is the only type which need be considered in detail here. The two factors which are most active in its production recall those of bronchiectasis, viz.: some weakening, perhaps congenital, of the walls of the alveoli, and increased tension in the bronchi and alveoli (forced expiration). This latter is produced most frequently by spasmodic, persistent coughing with the glottis partly closed. It is also seen in chronic bronchitis; indeed, the latter would seem to be the chief forerunner of emphysema, as it is of bronchiectasis. Unlike the latter, emphysema first makes itself felt in the upper lobes of the lung where the intravesicular pressure is most marked. The disease is seen in certain occupations, such as glass-blowers and players of wind instruments, but is then of a somewhat different type in that forced inspiration must precede forced expiration.

In considering the form which follows bronchitis and asthma, it is found that the persistent result of forced expiration is to alter the shape of the thorax and confer upon it a characteristic acquired deformity; the sternum and costal cartilages being thrown forward while the position of the ribs may in extreme cases become almost horizontal. This type of thorax may be congenital as a result of premature calcification and ossification (see preceding sections). True emphysema occurs in the young, principally as the result of whooping-cough and develops rapidly, but is capable of partial or complete recovery. The emphysema of the elderly forms a special type representing atrophy of the lungs. The typical form begins chiefly in adult life; it is of slow evolution and eventually becomes a chronic, incurable affection.

Upon opening the thorax of an emphysematous subject the lung does not at once collapse because the elastic fibers are few, while the thorax itself has become rigid and the costal cartilages calcified. If the condition has been chiefly unilateral, the affected lung compresses the mediastinum and the sound lung.

Symptoms.— In considering the symptoms, very many patients present a history of an original bronchitis or asthma, dyspnea being the most common symptom; this is slight at first but becomes progressive. It is an expiratory dyspnea, and is due to the inability of the

[1] Surgical asthma or asthma amenable to surgery.

lung to contract; thus, the air has to be expelled by the extrinsic forces of expiration; the patient at times seeks to expel the air by compressing the thorax with his hands. This form of breathing, which must increase the retained air, naturally interferes with the interchange of gases, and the paroxysms of coughing further increase the disorder. The right heart is with difficulty able to force the blood through the pulmonary circuit, slight cyanosis develops during paroxysms, and dilatation of the heart may begin early, despite a stage of compensatory hypertrophy. As the disease advances the thorax can hardly be said to expand; its sides are elevated during inspiration. Emphysematous cells have a tendency, during paroxysms of coughing, to rupture into the pleura or into the interstitial tissues of the lungs.

The Surgical Management of Emphysema of the Lungs.—An early surgical thought was to partly overcome the rigidity of the thorax by mobilizing it through rib resection. This was originated in 1859 by Freund,[1] but it was not carried out until comparatively recently. While favorable results have been reported by some the benefit has been considered doubtful by others, and even the principle has been pronounced faulty. Sauerbruch, in a measure, shares this latter view on theoretic ground. Friedrich,[2] on the other hand, saw a case benefited by operation, the benefit continuing even after an unexpected restoration of continuity at the point of resection. The partisans of the operation claim that it gives the ribs free play, removes the inspiratory position, and secures an expiratory reduction in the capacity of the thorax.

Selection of proper cases for operation seems to be very difficult. The subjective symptoms demanding operation are very vague—dyspnea on exertion, cough, bronchitis. Objectively there is the barrel-shaped chest, ribs running almost horizontally, and an epigastric angle of 90 degrees.

The vital capacity is reduced by one-half. Palpation and careful puncture with a needle show the abnormal condition of the rib cartilages. Inspiration is forced, and all of the auxiliary muscles are used in it. Expiration is prolonged, and at times stridulous. Cough is severely paroxysmal but there is very little expectoration. The spirometer and *x*-rays give information of value. Confusion is occasioned by the fact that similar changes in the costal cartilages occur in the paralytic thorax and in advanced age. Operation is by no means without risk, death having resulted in several instances.

Despite possible theoretical fallacies the immediate results of the operation are at times startling. Within twenty-four hours benefit may be felt. The vital capacity rapidly increases. Both inspiration and expiration generally show improvement. In some cases, however, this benefit is not maintained. The cartilages are capable of undergoing regeneration. The status of the operation must be therefore considered as still unsettled.

[1] Der Zusammenhang gewisser Lungenkrankheiten mit primären Rippenknorpelanomalien, Erlangen, 1859.

[2] Arch. f. klin. Chir., 1907, No. 4, vol. lxxxii.

Some internists have declared that all changes observed in the thorax are secondary to the pulmonary affection, and that consequently no operation for enlarging the thorax will be of benefit. Nevertheless, in 1912, report was made on fifty-seven subjects operated by Freund's chondrectomy with remarkably good average results. Merely the division of the last of the four costal cartilages has at times been sufficient to mobilize the thorax and notably increase the breathing on the side of the operation, although this breathing has fallen somewhat short of that on the opposite side.

Freund's operation has a twofold field—one for decompression (apical tuberculosis), the other for emphysema and asthma, mobilization of the rigid chest. (The latter principle may also be applied in various deformities, both congenital and acquired.[1])

The operation of chondrectomy is a thoracoplasty which removes the costosternal articulation and the costal cartilages and substitutes a fibrous or hinge-like union of the ribs and sternum.

In chondrectomy, it is the aim of the operator to detach from their sternal connections the second, third, fourth and fifth ribs, and to make them permanently mobile by cutting out their cartilages. These ribs are the only ones which unite directly with the sternum, excepting the first rib. The exsected pieces become replaced by a hinge-joint. The free ends begin a to-and-fro movement, separating during inspiration and approximating during expiration. In time there is a tendency to narrow down to a hinge-joint and even to close up. (This event must be prevented during the surgical intervention.)

The operation is usually unilateral—if bilateral it is done in two stages. A longitudinal parasternal incision is preferable. The periosteum or perichondrium must be destroyed. The anterior periosteum comes away readily with the rib, but the internal periosteum must be detached cleanly from the pleura by a suitable instrument. Accidental puncture of the pleura does no harm but is to be closed promptly. Bits of perichondrium are usually left behind, and from these new cartilage forms. To prevent this Andrews obliterates with sutures the groove or depression left by the cartilage.

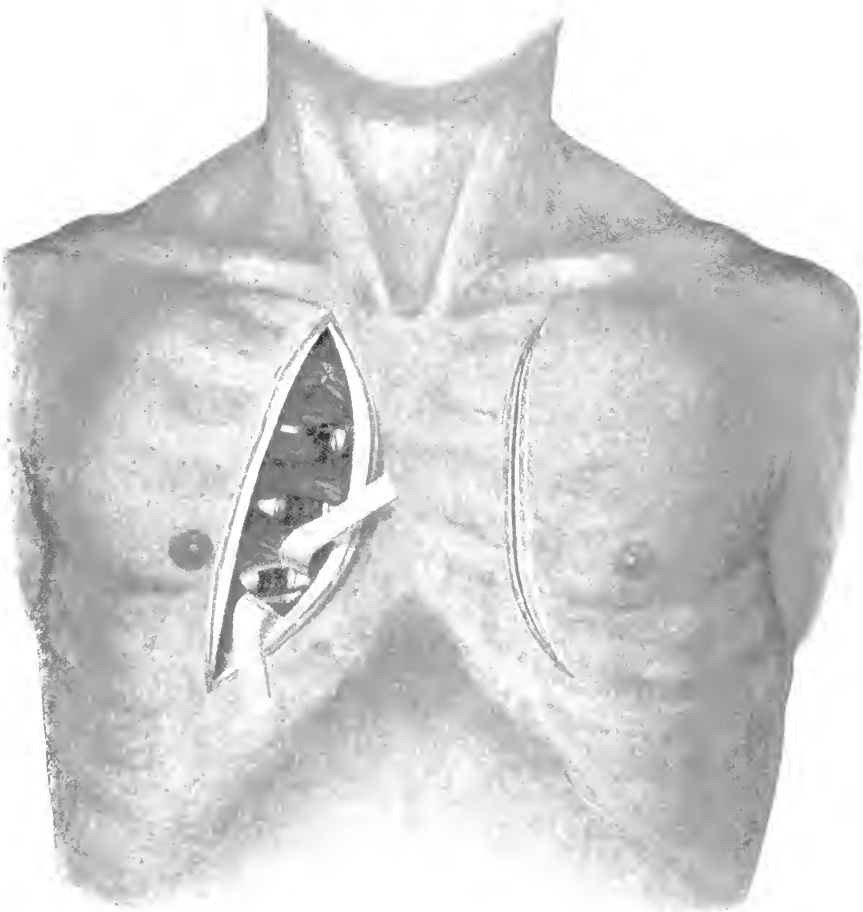
The relief, as already stated, is often surprising; the thorax expands and contracts well. Cyanosis often leaves the patient while he is on the operating table; he can lie down as he has not done in years and he can rest his diaphragm and neck muscles.

Only chests which are both rigid and dilated are apt to be helped by this operation. The ribs must be horizontal, the sternum pushed forward and the cartilages bowed and rigid. Inspiration cannot increase the chest circumference, expiration is slow and stridulous, there is cyanosis, and flattening of the diaphragm. The vital capacity is often less than 2500 c.c.—at times it is much less. The operation causes return of the power to expire.

Contra-indications are severe cardiac and vascular disease, fetid

[1] See article by E. W. Andrews: Jour. Am. Med. Assn., 1914, lxiii, 1065.

PLATE VII



Freund's Childrot mt Operation — Sauerbruch

bronchitis or bronchiectasis, costovertebral ankylosis, tonic rigidity of the intercostal muscles and paralytic rigidity of the thorax.

Local anesthesia may be used (nerve blocking of intercostals). There should be practically no mortality. It does not seem necessary to remove the first rib as was originally done by Tuffier.

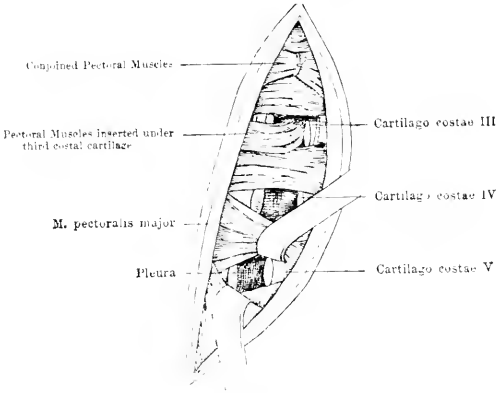


FIG. 182.—Scheme of Freund's operation.

Freund's Chondrotomy in Congenital, Rigid and Dilated Thorax.—An example of this condition is that of a child of two and one-half years, born apparently with a barrel-shaped chest, horizontal ribs and an enlarged heart occupying half of the thoracic cavity. The actual lesion was precocious calcification and ossification of the costal cartilages. In an attempt to save life from 1 to $1\frac{1}{2}$ cm. of cartilage was resected from the second to fifth ribs. In this particular case death took place from a pyocyanous infection.

THE SURGERY OF PULMONARY TUBERCULOSIS.

Outline of Original Efforts.—The first attempt in this direction was made by Hüter, operating for Mosler,[1] in July, 1873; incision and drainage were made of a tuberculous cavity in the lung. The same operation was done on a second patient two years later. In 1882, Forlanini began his experimental work on artificial pneumothorax; in the same year Ruggi[2] twice extirpated a tuberculous apex (both patients died). In 1888, Forlanini first performed his operation on a human subject, and in the same year Quincke made the earliest thoracoplasty (mobilization of the chest wall over a cavity by a resection of the ribs). In 1890, Tuffier resected a tuberculous apex and two years later performed his operation of apicolysis or extrapleural pneumolysis. Murphy independently introduced the operation of artificial pneumothorax in 1898, and was followed after an interval (1906) by Brauer.[3]

[1] Ueber Lungenchirurgie, 1883.
[2] La tecnica della pneumectomia nell' uomo, Bologna, 1885.
[3] Deutsch. med. Wchnschr., 1906, No. 17.

All of the more advanced surgery of the chest for tuberculosis is of comparatively recent date.

Not a few internists resolutely oppose all surgery of the tuberculous lung as being useless and meddlesome. Further, the very great majority of American surgeons adopt an extremely conservative course. Artificial pneumothorax is almost the only procedure which has thus far found even an approach to employment.

FIG. 183

FIG. 184

FIGS. 183 and 184.—Thoracoplasty according to Friedrich. Result two and a half months after operation. (+ apex beat.)

Nevertheless we find that Sauerbruch[1] had performed extrapleural thoracoplasty 122 times with 24 patients considered as cured and 6 notably improved (27 were not improved or were made worse, 2 died); Friedrich[2] had performed his operation of pleuropneumolysis 45 times; Wilms had done his operation of columnar resection 21 times.

The surgery of pulmonary tuberculosis is directed chiefly to the cavities which form at a relatively early period, and such surgery is equally applicable to other cavities, notably to those of bronchiectasis, and to some extent to those of abscess and gangrene.

Cavities may be dealt with by a number of methods; incision and drainage, prosthesis, pneumectomy, and compression or collapse. The latter results may be induced in a variety of ways, so that there exists

[1] Deutsch. med. Wchnschr., 1914, xl, 990.
[2] Med. Klinik, 1908, No. 33. Deutsch. Ztschr. f. Chir., 1909, vol. c.

a type of surgery known as the "Collapse" Surgery of the Lung. In the surgery of tuberculosis, "collapse" surgery constitutes the principal portion of cavitary surgery; for incision and drainage, prosthesis and pneumectomy play a minor role. A third form of thoracic surgery, known as decompression surgery, which consists chiefly in a simple division of the ribs behind or of the cartilages in front, has been employed in tuberculosis, but is not directed to cavities; the good results obtained would seem to consist of a better expansion of the lung.

The chief resources in the surgical management of pulmonary tuberculosis are as follows:

Cavitary Surgery:
- Incision and drainage.
- Pneumectomy.
- Collapse or compression methods.

Principal Interventions:
- Artificial pneumothorax.
- Extrapleural pneumolysis and grafting.
- Extrapleural thoracoplasty.
- Wilm's columnar resection.

Accessory or Indirect Methods:
- Phrenicotomy.
- Ligation of pulmonary vessels.
- Torek's interpleural pneumolysis.

Decompression Methods:
- Freund's chondrectomy.
- Wilm's columnar resection (in certain forms.)

Incision and Drainage.—This was an early (now largely abandoned) method of treating cavities, for it can hardly lead to the healing or closure of them. However, it has been revived in recent years in connection with extrapleural pneumolysis and prosthesis; resources that originated many years ago with the distinguished Tuffier.

Incision and drainage was originally meant to be an operation *per se*, or the application of ordinary surgical principles to tuberculous cavities. It was revived, in part, in connection with the plumbing or filling of collapse spaces with permanent and non-irritating substances, and was then intended as a mere addendum to other measures, or as a palliative treatment of cavities which could not be made to collapse by the usual methods.

The extrapleural pneumolysis, to be practiced before incision, is accomplished without resection. Since it is applied almost wholly to the apex it is known as apicolysis. (The operation is separately described.)

Simple incision and drainage is said to be in current use in some of the great tuberculosis sanatoria in Germany; it has been employed by Friedrich.[1]

[1] Maisel: Deutsch. Ztschr. f. Chir., 1914, vol. cxxx.

Pneumectomy.—Pneumectomy and lobectomy as typical operations are considered elsewhere. As applied to pulmonary tuberculosis such operations represent a type of intervention when cavities can be disposed of in no other way.

In 1882 Ruggi performed two pneumectomies: he was followed in 1884 by Krönlein[1] and Block.[2] In 1891 Tuffier made a successful resection and was followed by Lawson in 1892. Writing in 1903, Vautrin could collect but 6 cases, which probably corresponded with these cited. These early pneumectomies, however, were not all performed for the cure of diseased foci.

The work done by Macewen[3] in this direction has been phenomenal in character. As far back as 1895, he removed nearly the whole of an entire lung which was the seat of huge cavities. The patient was living and well in 1911 (Quincke and Garré). In 1895 (collapse methods had not then come into use), Macewen removed the fourth to eighth ribs, ligated the vessels at the hilus, and extirpated what was left of a lung save a small portion of the apex which was untouched for fear of wounding the subclavian artery.

Artificial Pneumothorax in the Treatment of Pulmonary Tuberculosis.—The general principles of this operation are considered elsewhere.

It is believed in many quarters that the operation originated with Forlanini of Pavia in 1882, this author having been incited to the work through a perusal of a French thesis by Toussaint (1880) which dealt with the improvement in tuberculosis as a result of natural pneumothorax. As a matter of fact, however, the idea is much older, having probably originated with Carson of Liverpool, in 1821. He showed that a lung, in animal experiment, could be collapsed with impunity, and proposed pneumothorax as a rest measure for pulmonary tuberculosis. Carson's ideas were not allowed to die; they were often mentioned as reasonable and were supported by the citation of cases in which traumatic pneumothorax and pleural effusions exerted a favorable influence on a diseased tuberculous lung.

Forlanini experimented on animals for years before he ventured to operate on the human subject (1888[4]) and several more years were allowed to elapse before he had enough clinical material to warrant submitting his results to the profession (1894). The operation was not taken up by the surgeons generally but was soon afterward independently set forth by Murphy.[5]

Sachs[6] reports on the results obtained by 24 carefully selected American observers. There were 1122 cases reported upon in the last few years, the incidence of various complications occurring in the course of treatment, being as follows:

[1] Berl. klin. Wchnschr., 1884, xxi, 129.
[2] Deutsch. med. Wchnschr., 1881, vii, 634.
[3] Tr. Internat. Congress, Moscow, 1897, v, 385.
[4] Potain is said to have made a therapeutic pneumothorax in 1888.
[5] Denver Meeting of the Am. Med. Assn., 1898.
[6] Jour. Am. Med. Assn., November 27, 1915, p. 1861.

Complications.	Number.
Pleural effusion	113
Extension of process in opposite lung	58
Bleeding of other lung	7
Pleural shock	26
Gas embolism	3
Spontaneous pneumothorax	10
Bilateral pneumothorax	2
Pyopneumothorax	13
Cardiac dilatation and heart failure	4
Torsion of heart and bloodvessels	1
Total	237[1]

One is forcibly struck by the very large percentage, 21 per cent. of complications occurring in the course of this assumedly simple procedure.

Murphy (1898) within a brief interval was able to report a very large number of cases through his associate Lempke, and this excellent presentation of the subject influenced Brauer to introduce the operation into Europe (outside of Italy). In the meantime Forlanini's work in Italy had begun to accumulate, where his operation had been accepted as a rational procedure. Despite his thirty-five years of experience, however, his amount of material is not large—very much below that of Murphy and his associates. Forlanini has made a very great number of individual injections, however, and is the most exhaustive and systematic writer on the subject, not only from his own viewpoint but from that of his contemporaries, to whom he has always been ready to award full credit. His writings are classic and the writer has freely borrowed from them a statement of indications and contra-indications. (Elsewhere will be found an account of the accidents which have resulted from the operation and the ways by which they may be avoided.) In addition to Forlanini and Murphy, others have operated on very many cases. The writer has definite knowledge of many cases operated on by physicians of Denver and Colorado Springs.

Indications for and Contra-indications to Artificial Pneumothorax.—Theoretically there are two principles involved: (1) the pneumothorax tends directly to relieve the destructive processes and the results of the same (cavities). This is purely a local activity. (2) Its action is unilateral. In other words it is a strictly local treatment of a unilateral tuberculosis. Nevertheless, experience has taught that the operation may not only improve the state of the opposite lung when it is slightly involved, but also that it tends to benefit extrapulmonary foci.

Pneumothorax is contra-indicated in affections of the circulatory system and kidneys because it exerts a disturbing influence upon the heart.

Factors of individual significance are (1) the character of the tuber-

[1] Twenty-one per cent. of the total number of cases.

culous process, (2) the condition of the pleura, (3) the co-existence of other diseases, (4) bilateral character of the disease, (5) stage of the phthisical process.

1. *Character of the Tuberculous Process.*—The operation is contra-indicated in general miliary tuberculosis, and in all acute forms. It may not harm the patient but it can hardly help him, as his life is directly menaced by the disease. Either the other lung or the organism at large is threatened. Generally speaking, the operation is restricted to cases in which life is not immediately threatened.

2. *State of the Pleura.*—A free pleura is a desideratum for a successful treatment, but this is not indispensable. It is, however, necessary that adhesions be not too extensive or too dense. It is often possible to recognize the presence of adhesions, but it is often very difficult to learn their amount and degree. Experience teaches that the pneumothorax often removes the adhesions; if not wholly, at least in part. Old, total symphysis of the pleura—a condition generally to be recognized—furnishes the only absolute contra-indication. In all other cases the operation may be attempted, and relinquished only when it is found that the amount of gas which can enter is quite insufficient for the purpose.

3. *Co-existence of Other Diseases.*—In theory, pneumothorax is contra-indicated in diseases of the circulatory system and kidneys. The pressure of the gas in the pleura not only compresses the heart but it prevents the ingress into the thorax of venous blood, thus increasing renal congestion. In practice, however, Forlanini has not experienced such ill-results; he does not hesitate to operate when there is good compensation in the heart and kidneys. In two cases of nephritis, the patients did very well following the operation. Diabetes constitutes a theoretical contra-indication not yet borne out in practice. The same may be said of laryngeal and intestinal tuberculosis. If these lesions are not severe Forlanini does not hesitate to institute treatment.

4. *Bilateralism of Pulmonary Tuberculosis.*—The unilateral location is simply the ideal condition. Bilateralism *per se* does not absolutely contra-indicate. If there is but a single circumscribed focus of disease in the second lung the operation may favor healing or arrest. The rationale of this successful outcome is not clear, for only in a minority of cases is it successful. The rule is for the focus in the second lung to progress, but while the presence of such a focus might seem to form a contra-indication the author would give his patient the benefit of the doubt. If there is a small circumscribed focus in each lung Forlanini operates first on one side and then on the other, counting upon the first lung to re-expand before operating on the second. Naturally the alternation of sides has some field in the more advanced bilateral cases, but these must be carefully selected for treatment.

5. *Stage of the Phthisis.*—The operation may be indicated in all three stages; in other words, the stage *per se* is immaterial. The more advanced the disease the greater the likelihood of bilateralism and the

greater the likelihood of dense, extensive pleural adhesions; conversely, the more circumscribed the lesion, the greater the amount of good lung tissue. When there are cavities there are likewise caseous foci present. These combined lesions form the cause of the most serious complication of the operation, a perforation of the lung.

Even in the simplest cases the treatment is long and exacting for both physician and patient and pleural infection may possibly take place. Medical treatment should by all means be instituted in beginning lesions. The moment ulceration of tissue begins the practitioner, however, may have recourse to the artificial pneumothorax.

Murphy's Technic for Artificial Pneumothorax.—This account is taken from an article by Murphy and Kreuscher in the Tuberculosis Number (March) of the *Interstate Medical Journal*, 1914.

"The patient is placed in a comfortable sitting position and the chest is bared over the side to be injected. The point of insertion of the needle varies somewhat in individual cases. If the apex of the lung be the site of the lesion, the needle should be inserted in the fifth or sixth interspace between the anterior and midaxillary lines. The best point is the fifth interspace at or near the anterior axillary line. If it be a middle or lower lobe tuberculosis, the injection should be made over the upper lobe, preferably in the fourth interspace just outside of the mammary line."

Local anesthesia (novocain infiltration) involving the injection zone gives very satisfactory results. A tenotome puncture through the skin precedes the introduction of the needle, this introduction being made before the tube is coupled on. In order to make sure that the needle is in the pleural cavity the patient is asked to take a series of deep inspirations. If the cavity has been entered an inrush of air will be heard, and after the forced respirations are under way air will be heard moving in both directions. The distal opening of the needle should be covered with a little cotton to serve as an air filter. The gas does not always readily enter the pleural cavity, doubtless because of the natural cohesion of the two laminæ of the pleura. It may be necessary to overcome a pressure estimated at $12\frac{1}{2}$ mm. of mercury. (The author apparently does not employ a manometer.)

The needle used is blunt, of moderate size and with a special side opening near the tip. Hence, if the tip chances to be occluded the gas can still enter the pleural cavity. When ready for use the needle is attached to a tube which communicates at its other extremity with a cylinder of nitrogen. From 50 to 200 cubic inches of the latter may be introduced at a time, the operator being guided by the symptoms of dyspnea and distress and the displacement of the mediastinal contents and the diaphragm. The needle is now withdrawn and the puncture is sealed with collodion over which is placed a firm compress which is intended to prevent a subcutaneous emphysema.

Results of Operation.—The average number of injections required appears, from Murphy's experience, to be about 5. Repetition is necessary because of the gradual absorption of the gas. The injec-

tions are continued until, if possible, the following typical results are obtained:

1. The decline or disappearance of fever, which marks the disappearance of toxic material from the lung cavities.
2. The diminution or disappearance of expectoration, which also points to the closure of the cavities; the bacilli of the sputum may also have disappeared.
3. A gradual increase in weight.
4. Improvement in hemoptysis.
5. General amelioration in a relatively short time.

The main desideratum, at present, is the earliest possible application of treatment in these cases. One should not wait for cavities to form because the lung can be collapsed and placed at rest in advance of a cavity formation; thus, the latter may be prevented. Rest is really the primary requirement, a collapse of the cavities is a secondary one.

Pneumolysis and Grafting in the Treatment of Cavities.—This combined resource is best described by Tuffier (see the Tuffier and Loewy article in the Tuberculosis Number of the *Interstate Medical Journal*, March, 1914). It has the advantage of immobilizing and compressing only the diseased portion of the lung.

In 1891 Tuffier resected the second rib with the idea of extirpating a tuberculous apex. The parietal pleura was found to be adherent to the ribs, but it was readily detached with the fingers. It then became evident that this pneumolysis could readily be used for diagnostic purposes. The apex could also be mobilized and the depression filled with grafts. This procedure Tuffier terms "extrapleural pneumothorax"; he regards it as superior to the typical or intrapleural form. (One judges that he has operated in this manner some 16 times since 1912.)

The completed technic of this procedure is as follows: first stage, "apicolysis" or detachment of the apex. An incision 6 cm. long is made in the second intercostal space down to the pleura, the muscles being divided separately. The author's intercostal separator, with a toothed rack, is then applied, and the parietal pleura, usually adherent, is exposed. The tip of the index finger now separates the pleura from the inner aspect of the ribs. The anterior surface of the apex is first freed, the posterior surface later. (This step is difficult, especially if there are vertebral and mediastinal adhesions.) The lung tissue, if pervious, collapses with each inspiration, so that in the process of the apicolysis cavities often sink in under the finger. As the apex is isolated it is protected with a layer of silk dipped in sterile vaseline. (This is intended to prevent rupture into the walls of a cavity.) The apex, now freed, tends to collapse, leaving a cavity between the parietal pleura and the ribs. This cavity is to be filled with fat, fresh or from storage. (Paraffin mixed with bismuth has been used.) These substances are used to distend the artificial cavity and thus compress the apex. The intrapulmonary cavity is obliterated as the lung retracts toward the hilus. The various superjacent tissues are to be separately sutured.

Evolution and Technic of Sauerbruch's Operation for Extrapleural Thoracoplasty.—The oldest and simplest method of rendering the thorax mobile and causing a depression is that recommended by Quincke and Spengler (1888). Everything subsequent in this direction seems to have been based thereon. Quincke recommended that one or several ribs over a cavity should be resected. (A piece of the second rib or of the second and third ribs sufficed as a rule.) Bier made an incision from the coracoid process to the sternal border of the first rib cartilage and subperiosteally resected the second and third ribs. Spengler thought that the amount resected should agree with the amount of diseased lung and spoke of "total resection." He removed 35 cm. from the third and fourth ribs at the anterior axillary line. (It is not necessary that the resection be over a cavity, although this should be the case when possible.) Turban[1] stated that a resection anywhere benefited the entire lung, and that a resection over the lower lobe was of benefit to the apex. He resected, at the lower lateral region, a wedge-shaped piece with its base downward. In one case his incision was at the anterior axillary line, removing 24 cm. from the fourth to seventh ribs. One year later he removed 41 cm. from the sixth to the ninth ribs. Landerer repudiated typical operations and operated on each case individually. He felt that one resected rib should be outside of the area of the cavity. He resected ribs both above and below—the three or four upper ribs or from the fourth to ninth, both anterior and posterior. None of these operations aimed at the collapse of anything more than the cavity itself.

Brauer repudiated all partial resections with a view to the securing of a total collapse. Friedrich and he developed a special technic which resembles in its incision the older Schede operation for empyema. (The operative details are given elsewhere. At least 160 cm. of ribs are resected, 25 of which are from the lowest (ninth or tenth) rib.)

After taking the ribs from the thorax the lung retracts "hilusward." Total collapse is the rule, but, in some cases, the apex remains uncollapsed, although the operation is usually intended to secure this result. This failure of the apex to collapse is due partly to the fact that the first rib is not included in those resected. Friedrich, in his earlier cases, instead of resecting the first rib preferred to detach the costal pleura by a blunt dissection (apicolysis). As a result of this the apex sinks in but no dead space is formed. No one else seems to have tried apicolysis, and Friedrich abandoned it for fear of a cardiac collapse from the "circulatory reflex." The only remaining course was to resect the first rib with the others, and this seems to have been first done by Sauerbruch. Brauer went further and advocated resection of the clavicle. Sauerbruch had seen benefit to the apex from an accidental fracture of the clavicle, and so resected it in a series of cases. Friedrich was the third to include this step. Sauerbruch performed this operation four times; he had two excellent results, and one fair

[1] Berl. klin. Wchnschr., 1899, No. 21.

result, but lost his fourth patient. Friedrich's operative mortality was also high. This was due, in part, to general causes, but especially to a state of affairs which corresponds to an open pneumothorax with paradoxic breathing and mediastinal fluttering.

It seemed necessary to improve the technic. Friedrich tried subperiosteal resection with regeneration, but this did not diminish the acute dangers. Firm bandages and retentive apparatus, overpressure, etc., were tested for the prevention of the paradoxic respiration, but something more radical was needed. Brauer selected the so-called Quénu-Tietze operation for old empyema cavities. This left a thoracic wall while admitting of some collapse.

The Boiffin method of paravertebral division of the ribs, also for empyema, allows of considerable retraction of the lungs. This method was introduced by Wilms in 1911 for the relief of pulmonary tuberculosis. This paravertebral division of the ribs reduces the capacity of the chest by 150 to 180 cm. Wilms substituted for simple division the resection of a certain number of ribs, parasternal as well as paravertebral.

Compression or collapse therapy differs radically from decompression therapy. The collapse of the diseased lung is encouraged. The earliest resource for this purpose was artificial pneumothorax which has already been described. This operation is practically limited to cases without pleural adhesions. Brauer was, therefore, moved to devise a procedure to produce collapse in cases with pleural adhesions. He chose an old resource tested by Quincke in 1888, and by Spengler in 1890. This was a resection of the ribs over a given tuberculous cavity (such a procedure as had been in use for an abscess of a lung), with the aim of securing a diminution in the size of a cavity and its cicatrization. Quincke operated in front, while Spengler made his resection in the interscapular space. The latter, with others, advocated a wide resection and called the procedure extrapleural thoracoplasty. The aim was to secure some retraction of the chest—not a collapse of it.

Brauer sought collapse and felt that the resection should be as extensive as possible. He advised a flap incision which encircled the scapula and exposed the chest-wall. Ribs, from the third to the tenth, were then removed in great extent. The intervention was a new one and Brauer termed it "Pleuropneumolysis thoracoplastica," but Spengler's original term has survived.

The operation was performed successfully by Friedrich,[1] but its mortality proved to be high, and technical modifications were necessary. It was at first done in two or even three stages. (The Küster-Estlander operation for old empyemata may also be performed for tuberculosis. Wilm's columnar paravertebral resection may be regarded as an outgrowth of empyema surgery as practiced by Boiffin.)

In considering the rationale of extrapleural thoracoplasty, it may be

[1] Friedrich being the Director of the Surgical Clinic at Marburg while Brauer was the Director of the Medical Clinic.

well to discuss again the artificial pneumothorax. In this latter procedure, the gas introduced tends to abolish the normal adhesion of the pleural laminæ. The chest no longer produces traction on the lung and the elasticity of the latter causes it to retract. It becomes smaller and smaller and if enough air is allowed to enter the pleural cavity it may attain a minimum of size. Atelectasis does not result until the air has been absorbed. With the retraction of the lung, given cavities collapse, the respiration is retarded and the lung tends to be placed in a state of functional rest. The type of respiration is reversed. Air from the sound lung passes, during expiration, into the still distensible collapsed lung. During inspiration this air again escapes, as the latter contracts.

The collapsed lung can no longer make traction on its environment, and as a result the mediastinum is thrown from its equilibrium and is displaced to the sound side so that the sound lung has its excursions diminished. In a like manner, the diaphragm descends during inspiration as a result of the change in intrapleural pressure. Hence, slight dyspnea and acceleration of the heart's action may result for a brief interval or until an equilibrium is regained.

Functional rest and diminution in the size of the cavities are important therapeutic factors, akin in every way to the placing at rest of tuberculous joints. There can naturally be no collapse if the walls of the cavities are rigid. Other phenomena are not so readily understood, such as the action of retraction of the lung on the bloodvessels. The latter must undergo some compression and the heart is displaced with the mediastinum. Less blood reaches the right ventricle, but accepted authorities differ widely as to the exact rationale of that which occurs. In an open pneumothorax the blood circulates freely through the collapsed lung and the writer, for the sake of argument, assumes that this must be the case with a closed pneumothorax. This view is disputed, however, by those who disbelieve in a free circulation through a given collapsed lung. There is blood enough in the latter, but they think it stagnant.

Atelectasis occurs after the alveolar air has been absorbed. The vessels must undergo contraction, and as a matter of fact the lung receives less blood. (The argument refers to the period before atelectasis.) Brauer's view of an active hyperemia of the collapsed lung receives aid from Cloetta's researches, from which it appears that in the expansion of the normal lung there is a lesser blood supply than in a retracted lung. The greatest amount of blood is found at a pressure of about 3 cm. Hg. Sauerbruch confesses himself obliged to leave the matter undecided.

More is known of the lymph circulation. A retracted lung causes a lymph stasis. After collapse from pneumothorax there may be an initial fever from the absorption of toxins in the lymph. All are agreed that in a given pneumothorax lung changes occur in the pulmonary tissue. This becomes firmer and quite devoid of air. Very soon evidences of a transformation into connective tissue are present; tuber-

culous foci are invested, encapsulated and finally obliterated. These changes agree with those seen in any tissue. When recovery takes place as a result of a connective-tissue proliferation caused by the irritation of toxins it is probably due, in the contracted lung, to the stimulus of the toxic and stagnant lymph, although to some degree the same changes occur in a sound pneumothorax lung. A high degree of sclerosis of the lung follows ligation of the pulmonary artery (Sauerbruch) and of the vein (Tiegel). The changes in a collapsed lung agree with those caused by the ligation of a main bronchus; the metabolism in the collapsed lung is much lessened.

To return to the old Quincke-Spengler operation of rib resection, the authors mentioned the indurated thickening of the walls of the cavities and their adhesion to the chest wall, factors which prevented the collapse of the cavities, and stated that in the absence of these factors a collapse of the cavities would doubtless occur. In the more elastic ribs of youth these factors are less important than in the case of a rigid thorax in which the ribs are an added obstacle to the closure of cavities. This simple reasoning appears rational, and agrees with the conditions in bone tuberculosis and in empyema, in both of which conditions plastic operations are done with the object of mobilizing the outer walls of the given cavities.

In the operation of Friedrich and Brauer, however, not merely isolated cavities but the entire lung must be made to contract. A wide resection of the ribs must be made in order that the condition of artificial pneumothorax may be paralleled. A small resection of the ribs may be sufficient to cause a collapse, *i. e.*, an active retraction, but this retraction will not be complete.

Under physiological conditions the normal contractility of the lung cannot be exerted, as it is offset by the pull of the thoracic wall. This pull is no longer exerted when entire ribs are removed. The lung then retracts toward the hilus exactly as it does in an artificial pneumothorax. The other phenomena which accompany and follow artificial pneumothorax are also present (displacement of the mediastinum, dyspnea, etc.). The soft tissues deprived of bone are forced by atmospheric pressure against the lung beneath. (The pressure is less marked than in pneumothorax.) The paradoxic respiration, akin to that seen in open pneumothorax (contraction during inspiration, etc.), is characteristic. Hence, the immediate danger.

Aside from the shock attending the operation, the patient's color, at first pale, becomes increasingly cyanotic. Respiration becomes frequent and superficial; the pulse becomes small and rapid and the patient may die of dyspnea.

In favorable cases the patient adapts himself to the new conditions. The critical period is from the sixth to seventh day. If death occurs during this time, it is largely due to primary insufficiency of the heart.

The paradoxic breathing is connected with the mediastinal fluttering in closed pneumothorax, and does not occur save with a supple mediastinum. As long as these phenomena persist one cannot say that the

PLATE XIII

lung is at rest, although it no longer performs its functions. There is, as already intimated, a close parallel throughout between the two conditions; this also includes the changes in the collapsed lung and the therapeutic effects. The patients upon whom thoracoplasty is performed are, however, in a more advanced state of the disease, both locally and constitutionally. The cessation of expectoration after thoracoplasty is due in part to an inability to raise, a factor of importance in the prognosis.

Sauerbruch does not endorse the Brauer-Friedrich operation as recommended by them, and has been in favor of so modifying it that the paradoxic respiration can be practically excluded. He discusses two possibilities, viz.: a 2- or 3-stage operation, and a partial, plastic procedure. By the former he has had results claimed to be equal to those of the one-stage operation, and with much less danger to the patient. This seems a step back to the Quincke-Spengler operation which fails to give functional repose to the entire lung, much of which

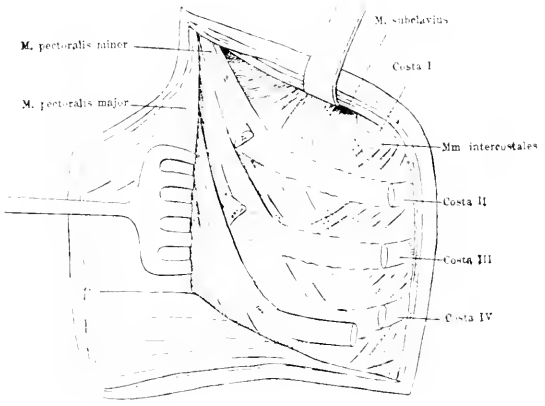


FIG. 185.—Rib resection to secure collapse of parietal wall.

still remains in contact with the chest-wall. Such a procedure is by no means equivalent to an artificial pneumothorax, and is merely a local resource indicated only when the pulmonary lesion is circumscribed. The most it can do is to cause a partial healing of the given cavity and to improve the general condition. The operation is, moreover, not free from risk, as some of the contents of the cavity may be aspirated into the sound lung. The thought of Turban that such intervention can aid the entire lung seems hardly warranted by the facts.

Of local resections, the Boiffin-Wilm's paravertebral is preferred, as giving better retraction than do the anterior or lateral resections. The incision should be carried, if necessary, to the eleventh rib. The respiratory activity of the lung is reduced to a marked extent, almost as much as in the extrapleural thoracoplasty. This is often the case when only the ribs over the lower lobes are resected, because the excursion of

these ribs is much greater than is that of the upper ribs. Resection of the lower ribs is often of benefit to the upper lobes.

In regard to the blood and lymph circulation in the partially retracted lung, the former is probably most complete at a pressure of 3 mm. Hg, or at about that of expiration. There is also probably a slowing of the lymph circulation.

Sauerbruch has resected the eighth to tenth and eleventh ribs for tuberculosis of the upper part of a lung. An ordinary paravertebral incision is bent at its lower end to form a hood. The scapula, free behind, can be turned forward. Beginning at the eleventh or tenth rib, 10 cm. are excised, and this length is reduced as succeeding ribs are resected. The number of these resected ribs depends upon circumstances. In total cases, all of the ribs up to the second or first are removed, the amount resected being 4 or 5 cm. over the upper portion of the lung. In certain cases, the first and second ribs may be resected in a second stage. A portion of the clavicle is sometimes removed.

Concerning the effect of lung retraction on the sound lung, it is found that the latter is forced to do more work and at the same time it is mechanically hindered from so doing. There results a tendency to emphysema from the dilatation of alveoli. Sometimes compensation is so marked that one may speak of the lung as being hypertrophied.

If the lung is already the seat of old, closed foci these may be thrown into activity. As regards the disappearance of expectoration, it must again be remembered that for the first few days this may be due to an inability to cough. This retained sputum must be expectorated, and after this there may be a sudden or a gradual diminution. The character of the sputum undergoes a radical change. The temperature, after a brief rise from absorption, begins to fall. A gain in weight is generally to be noticed.

The Evolution of Friedrich's Large Flap Operation (Including Division of the Phrenic and Intercostal Nerves).—In 1907 Friedrich[1] first practiced his extensive resection in the thought of securing for the diseased lung a complete rest, and its elimination from respiration. At the same time the cavities were to be closed by compression. The results seemed to justify the operation although the operative mortality was 25 per cent. In 1911 he was able to report 28 cases.

In different articles Friedrich discussed possible changes in technic: decreasing the amount of resected rib, operating in stages, the choice of the area to be resected, etc. Other surgeons, notably Sauerbruch and Wilms, took up the work and modified the indications so that milder cases were included. It gradually became apparent that too small an area of resection had its drawbacks, and Sauerbruch and Wilms began to employ the "hook incision" and "columnar" resections respectively. The former corresponded largely to Friedrich's incision of 1908. Danish, Swedish and French surgeons have performed the operation, especially such tuberculosis specialists as Turban, L. Spengler, Van Voornfeld, von Muralt.

[1] Arch. f. klin. Chir., 1914, cv, 429.

According to these authors, the fixing of the indications does not seem to be so very difficult. Even patients who have been bedridden for months and who have a high, hectic, intermittent fever and night-sweats may be included if the active lung affection is strictly unilateral and the other lung efficient for function. The better the general nutrition, as estimated by the state of the muscles, the better must be the prognosis. A yellow, pallid, withered skin which suggests intestinal tuberculosis, is a strong contra-indication. Any recent tuberculous metastases contra-indicate operation. Vascular erethism and a rapid, small-wave pulse, however, do not contra-indicate. (Such may be improved by digalin given before operation.)

The condition of the lung seeming to indicate operation is that in which a tendency to retraction is already present. The affected side is flattened, the clavicular fossa is retracted, the intercostal spaces are narrowed, and the muscles are sclerotic with an increased resistance to pressure; the intercostal spaces are narrower. Percussion and *x*-ray examinations show an attraction of the heart and mediastinum toward the contracted side; a high and at times a fixed position of the diaphragm; a shortening of the transverse diameter of the thorax on the affected side.

The lung evidences which contra-indicate the operation are progressive infiltrative processes of great extent, and miliary tuberculosis. A progressive increase in sputum raises a question, much more so than do increased bacilli. Cavities are not the main indication, for non-cavernous cases demand consideration as does the question as to whether one lobe or the entire lung is involved. If the sound lung has pleural adhesions, the outlook is not as good as when such adhesions are absent. Decision must finally depend on the most careful examination of the sound lung. The latter need not be absolutely intact. Old, passive foci, even when of considerable size, do not entirely contra-indicate operation. Even in cases of recent infection of the sound lung an improvement has been secured, as it has been produced by an artificial pneumothorax. The operation should, however, generally be confined to the unilateral cases. Although in cases with 300 cm. of daily sputum an operation has caused the disappearance of this within a few days, the fact remains that the "drier" the case the less will be the dangers of the after-treatment period. Cases with not over 10 cm. of daily sputum offer a favorable prognosis.

It cannot be said that, at this time, there is a typical operation. In extensive tuberculosis of one side, especially with cavities, an extensive rib resection will, of course, be required. The question of one, two or three stages depends on the resistance of the patient and the skill of the operator. In non-operative cases a tuberculosis of the upper lobe often leads to aspiration tuberculosis in the lower lobe, but this does not imply the existence of a physiologic law. It is not easy to understand why it is that, after a low resection, aspiration tuberculosis does not occur more frequently, respiratory movements being still present. In order to cause a maximal retraction at the apex, it is probably best to

cause a retraction of the lower lobe as well. In a two-stage operation the lower resection should be practiced first.

In order to secure a compression from behind, Friedrich has carried his resection as nearly as possible to the vertebræ. If large segments of ribs are left a collapse is hindered. Preservation of the anterior parts of the ribs, on the other hand, serves to protect the mediastinum, while resection here is not of much value in securing collapse, the anterior stumps of the ribs in reality following the pull of the lung.

Before operation (which may and perhaps should be done under local anesthesia), the patient clears his lungs of sputum. In order to prevent the chance of aspiration the operation should, in theory, be performed as rapidly as possible. (Friedrich was formerly proud of his ability to remove ten ribs in twenty-five to forty minutes!)

Beginning with 1909, Friedrich used an axillary incision, in many cases removing from the first or second to the seventh to ninth ribs. In disease limited exclusively to one lobe, a limited resection may be permitted; this when a cavity is present.

The condition of affairs is simplest in cases of isolated tuberculosis of the lower lobes. Here a resection is indicated which includes the tenth and fifth ribs, with the retention of the periosteum and a strong, obliterating suture of the soft parts, in order to obtain a firm chest-wall, good lung compression and rest.

In 1909, Friedrich described extrapleural apicolysis, or blunt separation of the apex and both pleural membranes from their environment. This may be used as an accessory to rib resection. Bär[1] has associated apicolysis with a plumbing of given cavities with paraffin (1913). Both Friedrich and Sauerbruch advise against such plumbing.

In regard to Stürtz's operation of phrenicotomy, Friedrich investigated the subject and made animal experiments. He also studied the relations of the phrenic nerve in subjects with enlarged cervical lymph nodes. (In one patient the nerve adhered to the internal jugular vein and in seeking to free it a fatal air embolism occurred.) Under normal conditions division of the nerve is simple; it should be divided as nearly as possible to the pleural capsule in order to get below the fourth cervical nerve.

Stürtz introduced phrenicotomy as a substitute for extrapleural thoracoplasty in cases of adherent pleura. The negative pressure in the thorax "sucks up" the paralyzed diaphragm on inspiration, while the abdominal pressure is increased by the compensation of the sound half of the diaphragm and thus forces upward the paralyzed side. Stürtz believes that the paralyzed half adapts itself to the contraction of the lung which it follows. Hellin assails the views of Stürtz and states that division of either one or both of the phrenics does not cause paralysis. Friedrich strongly disbelieved in abolishing the function of the phrenic nerve which is so essential for the act of coughing. Instead of cutting it he crushed it with an artery forceps after a diagnostic electrical

[1] München. med. Wchnschr., 1913, No. 29.

stimulation that caused a sense of dyspnea. The patients on whom he did this received no benefit either subjective or objective. The *x*-ray showed that the half of the diaphragm on the affected side at once rose and that it moved in unison with the sound half while the intact half of the chest showed a notable increase in volume. Pleuritic adhesions at the base of the lung prevented the change of place of the diaphragm. With basal adhesions there are usually adhesions of the mediastinum with a consequent rigidity.

If phrenic division be followed by marked decrease in expectoration, this can well be due to decreased ability to cough. Hence, in any consideration of this procedure, it should not be performed in the presence of profuse expectoration.

In 2 of the 6 cases in which the diaphragm ascended after phrenicotomy, Friedrich could find no evidences of improvement.

Consideration must be made of the question as to whether division or resection of the intercostal nerves tends to favor contraction of a given lung; it is known that division of these nerves renders the act of coughing nearly or quite impossible.

Friedrich, in one of his cases, divided the phrenic nerve on one side and resected long segments of each of the intercostal nerves. (This intercostal nerve excision was easily made through a long, vertical incision.) In a second case this surgeon combined resection of the intercostal nerves with an extensive resection of the ribs. In the first case his patient found it very difficult to cough. In his second case remarkable benefit is said to have resulted. It should be remarked that the pleura may be wounded in this nerve excision, in which event it should be repaired promptly.

Schepelmann, in 1913, divided the phrenic nerve and the twelve intercostal nerves, together with all of the nerve filaments leading to the scaleni muscles from the cervical and brachial plexuses, so that the lung was entirely functionless. Improvement is said to have resulted.

Wilm's Operation of Columnar Resection of the Ribs to Narrow the Thorax in Tuberculosis.[1]—This is not a decompression operation but one of "collapse" (compression) surgery. Wilms has operated under local anesthesia on 24 cases, with morphin (scopolamin, when necessary) given in advance. A longitudinal incision is made through the skin and muscles (separation of muscle fibers) from the second to the ninth rib, 3 to 4 cm. from the spinous processes of the vertebrae. Despite their division or separation, the trapezius and rhomboid muscles generally retain their functions, this perhaps due in part to the sinking in of the chest. (Newly formed scar tissue may give the muscles a new point of purchase.)

In freeing the ribs the intercostal vessels are to be spared. (In but 2 of Wilms's cases was the pleura injured.) In from seven to nine ribs, from 4 to 5 cm. of bone are removed. Approximately six to eight weeks later, this first operation is followed, in severe cases, by a parasternal resection.

[1] Therap. d. Gegenw., 1913, liv, 17.

The degree of compression here obtained is inferior to that produced by an artificial pneumothorax. The operation should be performed only after artificial pneumothorax has failed. The indications comprise conditions of the upper lobes in which sclerosis is accompanied by cavity formation. (Note the value of *x*-ray pictures in this connection.)

Pneumolysis Interpleuralis.—F. Torek, of New York, refers to cases of very dense and extensive pleural adhesions, in pulmonary tuberculosis, that cannot be remedied by the artificial pneumothorax. Even if the lower portions of the lung show collapse the heavy pleural adhesions about the upper lobe may prevent its necessary collapse. (In fact, it is pointed out that complete collapse in this locality is very difficult to obtain by the ordinary "collapse" treatment.)

The operation of extrapleural thoracoplasty may be said to be indicated when nitrogen, which enters the pleural cavity under pressure, is unable to separate the adhesions. Such intervention may be very severe in broken-down patients, although the two-stage procedure lessens this severity to some extent. Torek has, therefore, believed that these adhesions might be separated by the fingers without sacrifice of the thoracic wall. This process, which should not be confounded with extrapleural detachment of the lung, is termed by him, "interpleural pneumolysis."

The operation is performed with intratracheal insufflation narcosis or with the pressure-difference cabinet. A long incision (15 cm.) is made in the sixth or seventh intercostal space, at the posterolateral portion and carried down to the pleura. The latter is opened, after careful hemostasis. (The patient's head hangs well downward so that the contents of a given cavity can escape by the mouth without entering the opposite lung.) The ribs having been well retracted the fingertips begin to separate the adhesions close at hand. Gradually the fingers and even the entire hand may be introduced in order to complete the isolation of the lobe. If band-like adhesions have formed it is best to divide them rather than tear them. When the adhesions have been well broken up the lung tissue partially collapses. (It is best to leave this undisturbed.) The external wound is closed by periosteal, muscle and skin sutures, without drainage. This operation may be looked upon as preliminary to an artificial pneumothorax, if an *x*-ray diagnosis shows the latter to be practicable.

The possibility of rupture of a large, thin-walled cavity into the pleural sac occurs in various operations. The most common result of such an accident is a valvular pneumothorax, which in the case of an air-tight suture may lead to an emphysema or to an infection. Both of the accidents happened in a case of Torek's.

Further Remarks on Phrenicotomy as an Accessory Procedure in the Collapse Therapy of Pulmonary Tuberculosis.—It has already been stated that this procedure was suggested by Stürtz[1] for severe, chronic, uni-

[1] Deutsch. med. Wchnschr., Bd. xlviii.

lateral affections of the lower lobe, especially when cavities are present. The aim was to paralyze the diaphragm beneath the affected lobe of the lung and thereby, indirectly, cause a partial collapse of it. The operation, like numerous other procedures, is indicated in cases in which pleural adhesions prevent the establishment of an artificial pneumothorax. It is needless to say that it is a much simpler intervention than is thorocoplasty.

Against this intervention it has been urged that the diaphragm is fixed by adhesions in those cases in which it seems indicated. It has further been claimed that the diaphragm is but little affected by phrenicotomy. Wilms, after a study of phrenicotomy, believes that the diaphragm, as a result of this intervention, not only comes to a state of arrested movement but that it ascends in the thorax.[1] (See also Friedrich's operation.)

A recent and systematic consideration of phrenicotomy, contributed by one of Sauerbruch's associates, shows that the operation was adopted in the Zürich Clinic as a typical procedure. No less than 26 cases were reported. Of these, the operation was solitary in a few cases, while in the others it was done as a preliminary to an extrapleural thoracoplasty. In the solitary operations the results are said to have been good. It seemed to have been shown that after division of the phrenic nerve the diaphragm was arrested at its maximum expiratory position.

Phrenicotomy is performed with the patient half seated, the head thrown back and the face turned from the side to be operated upon. At the posterior border of the sternomastoid muscle, two fingers' breadth above the clavicle, a small depression may be felt. Beneath this lies the scalenus anticus muscle. An incision is made through the skin across this point, transverse or oblique, and the subcutaneous fat torn through. The scalenus is thus exposed with the phrenic nerve running along its anterior surface. The nerve is isolated and divided or resected. The instrument which grasps or divides the nerve causes a sensation of painful contraction. (Local anesthetic employed.)

Ligation of the Branches of the Pulmonary Artery for the Artificial Production of Atrophy of the Lung.—Sauerbruch and Bruns,[2] independently, as a result of experimental investigations, have arrived at the conclusion that ligation of the principal branches of the pulmonary artery ordinarily produces no definitely injurious consequences. Interruption of the circulation does not seem to lead to the production of infarcts. After having been tested thoroughly on animals, this operation of ligation was performed on a number of human subjects by Sauerbruch and Schumacher.[3] By ligating proper branches the various lobes can be made to undergo atrophy. The authors give the technic for ligating the branch which supplies the left lower lobe. The chest is freely opened in typical fashion by an incision in the fifth intercostal

[1] Deutsch. Ztschr. f. Chir., 1914, cxxix, 654.
[2] Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1911, xxiii, 343.
[3] Technik d. Thorax chirurgie, 1911.

space (ordinary thoracotomy.) As dense pleuritic adhesions are often present great care must be taken not to injure the lung. If no adhesions are present it is fairly easy to expose the vessel. The upper and lower lobes are separated at the interlobar notch thereby exposing the pedicle of the lower lobe. Here lie, close together on their way to the lobe, the artery, vein and bronchus, the latter lying below the artery and above the vein. By using little pledgets of gauze on a suitable instrument the structures may be isolated.

On account of anatomical variations these structures are not always quite accessible. In one of Sauerbruch's cases he was obliged to ligate the separate twigs of the arterial branch. (The ligature is simply passed around the vessel and tied in the usual manner.) A filament of the vagus may be accidentally included in the ligature, as shown by the sudden slowing of the heart, but no permanent damage seems to result from this accident. If there are adhesions between the lobes they may generally be detached without very much difficulty.

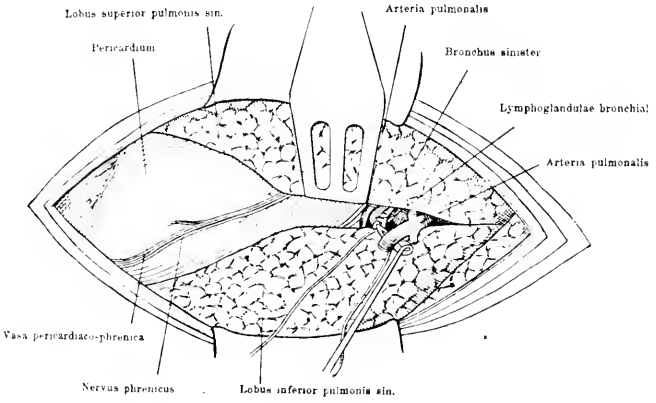


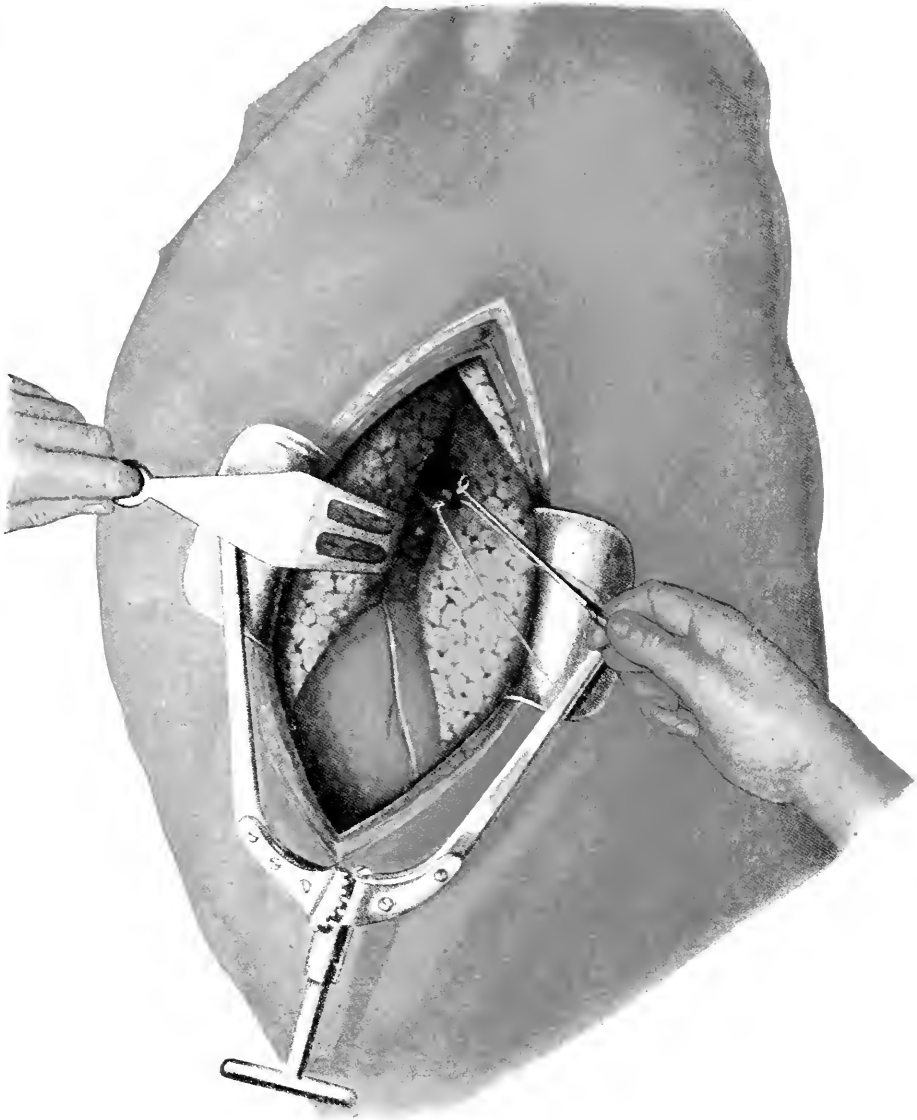
FIG. 186.—Ligation of pulmonary artery.

As a result of this ligation the lobe undergoes an abundant proliferation of connective tissue with compression of the alveoli; dense adhesions usually form between the pleura and the lung. The entire lobe contracts. (In one of Sauerbruch's patients a scoliosis developed.)

In order to complete this operation a thoracoplasty must be performed in order that the thoracic wall may be made mobile and thus follow the "pull" of the lung. This thoracoplasty may be done six weeks after the original operation; from 10 to 15 cm. should be resected from each of several ribs.

Freund's Decompression Operation (Chondrotomy) for Tuberculosis.—Because the apex is most frequently the initial location of pulmonary tuberculosis it has been assumed that this portion may be unduly compressed by the upper part of the thorax, in those predisposed to the disease. According to Freund's original conjecture, made as far back as 1856, this stenosis of the upper aperture of the lung consists

PLATE IX



Ligation of the Pulmonary Artery of the Left Lower Lobe.
(Sauerbruch.)

essentially in a congenital shortness of the first costal cartilage, which shortness inhibits the function of the pulmonary apex to a greater or lesser degree. This seems, in certain cases, to be offset by a relaxation of the cartilaginous tissue of the first rib, due to a distintegration of its structure, so that in extreme cases a false joint forms between the rib and sternum; it is in these particular cases that patients with apical tuberculosis often show a marked improvement.

Freund's thought was that whenever the cartilage is too short the condition should first be antagonized by respiratory gymnastics. If these are without benefit or if ossification is already present, chondrotomy should be performed on both sides. If the second rib is similarly affected, the operation is contra-indicated.

An *x*-ray examination and estimate should always be made before surgical intervention. The clinical evidence is chiefly based on an inability of the apex to expand fully on deep inspiration.

At operation an incision is made just below the clavicle and the pectoralis attachment is drawn aside; the arm should be abducted and raised as high as possible. Below the sternal end of the clavicle may be seen the termination of the first rib. The soft parts are bluntly dissected off and the entire cartilage is exposed. The anterior perichondrium is then divided horizontally and the two flaps pushed bluntly off above and below. Division of the cartilage with a suitable forceps is made within the perichondrium. The subclavian vein and pleura are to be carefully protected from injury. A half centimeter of tissue may be resected; this indeed, appears to be the typical operation (chondrectomy.) The posterior perichondrium is not disturbed and the empty space surrounded by this membrane may easily be filled with a piece of the pectoral muscle. (Wyllys Andrews.)

Views of the Writer Regarding the Employment of Surgical Procedures for the Relief of Pulmonary Tuberculosis.—In 1908 the writer visited Friedrich, then at Marburg, and witnessed thoracoplastic procedures at his hands, as well as experimental work done by Sauerbruch, at that time his "privat docent" in surgery. In 1911, the writer spent some time in the clinic of Wilms at Heidelberg, and saw a number of operations, columnar resection, done by this surgeon, together with patients who had previously been submitted to operation. He was much impressed by what seemed to him to be the rational grounds on which these extrapleural procedures are founded, and firmly believes that the surgery of the future will develop and tend to perfect operative work along these lines. In a paper read before the American Surgical Association at its meeting in 1909 the writer stated: "I venture the thought that it is probable that surgical aid will be extended to the victims of pulmonary tuberculosis more successfully in the future than it has been in the past, and that this aid will lie in the direction of lung shrinking without permanent pleural opening." The writer definitely feels that at this time (June, 1920) he would further emphasize the view thus expressed.

WOUNDS OF THE CHEST.

By DENNIS W. CRILE, B.S., M.D.

Introduction.—Wounds of the chest range all the way from contusions and abrasions of the skin or superficial tissues with fractures of the ribs or scapula or sternum to extensive blown out wounds of the chest wall with tearing and mangling of the lung, diaphragm, liver, pericardium and heart, and fractures of the spine. Rarely the esophagus or thoracic duct is injured. Nearly all wounds of the lungs are complicated by wounds of the bloodvessels. However, one seldom sees living patients with wounds of the great vessels of the chest. Generally in wounds of the lung, there is hemoptysis, indicating that a bronchus or bronchiole, or at all events an alveolus has also been injured, thus allowing blood to escape through the bronchial system.

Since we shall deal with major wounds of the chest, the lesions will be chiefly complex, involving skin, muscle, pleura, lung, air spaces, bloodvessels and sometimes bone. And since the missile or a secondary missile, such as clothing or dirt, often fails to pass out again, we have also to deal with foreign bodies.

Wounds of the lung or pleura may be accompanied by wounds of the mediastinum, the heart, the thoracic duct and of the diaphragm.

The possibilities of complications, then, are:

1. Hemorrhage.
2. Hemothorax.
3. Anemia.
4. Pneumothorax.
   (*a*) Pulmonary in origin.
   (*b*) Parietal in origin.
5. Infection.
   (*a*) Parietal in origin (sucking wounds).
   (*b*) Pulmonary in origin.
6. Collapse of lung (including the phenomenon of contralateral collapse).
7. Insufficient aëration.
8. Displacement of mediastinum.
9. Hernia.
   (*a*) Of abdominal organs through diaphragm.
   (*b*) Of lung through parietal wound.
10. Emphysema.
11. Fractures.
12. Any combination of the above.

The vicious results of these complications may be:

1. Death, the result of:
   - (*a*) Hemorrhage.
   - (*b*) Shock.
   - (*c*) Insufficient aëration.
   - (*d*) Sepsis.
     1. Local phlegmon.
     2. Infected hemothorax.
     3. Septicemia.
     4. Pneumonia.
     5. Secondary hemorrhage.
2. Loss of function, the result of:
   - (*a*) Organization of large hemothorax.
   - (*b*) Adhesions walling off a large empyema.
   - (*c*) Fibrosis of the lung.
3. Chronic sinuses, the result of:
   - (*a*) Retained foreign bodies.
   - (*b*) Retained sequestra.
   - (*c*) Adhesions preventing the lung from filling large dead space.
4. Pain, the result of:
   - (*a*) Pleural and diaphragmatic adhesions.
   - (*b*) Retained foreign bodies.
5. Dyspnea, the result of:
   - (*a*) An unexpanded lung.
   - (*b*) Diaphragmatic adhesions.
6. An acute exacerbation of latent tuberculosis (rare).

The methods used to prevent these bad results and of dealing with them when present are discussed hereafter.

Superficial Wounds.—It will not be necessary to occupy much space with a description of the simple superficial wounds of the chest-wall—as they require no specialized treatment—but one cannot pass them over without saying a few words about the differential diagnosis of non-penetrating and penetrating wounds.

Diagnosis.—A wound which is open—that is, one in which the entrance and exit wounds merge into a single wound—can be inspected. One can see the scratched or grooved ribs at its bottom and can trace its course. If the ribs have been shattered and severely comminuted, one may be practically certain that the pleura has been damaged and that infection may have entered the cavity. This type of wound, often knocks the patient down upon the ground where he at once claps his hand over the large wound and thereby fills it with microbes. Thus this type of wound is practically certain to be infected. The projectile passing through the clothes and skin makes a tiny hole hardly discernible that does not offer so excellent an opportunity for auto-inoculation. A single lacerated wound is more apt to be non-penetrating than the double punctate wounds of entrance and exit. It is true that some entrance and exit wounds are not penetrating, but they are generally wounds through some thick muscle, as the pec-

toralis, latissimus dorsi, trapezius, erector spinæ or the shoulder. The location usually tells whether a wound has penetrated or not. If its course lies through the ordinary boundaries of the chest cavity, particularly if well inside those boundaries, it has penetrated in almost all cases. The author has seen many cases in which the course of the projectile had apparently passed through the ordinary boundaries of the pleura but which proved at operation to be entirely extrapleural. This can be best explained by the assumption that the victim was in an extraordinary attitude when the missile struck him. But it is difficult to accept this theory in all cases.

The Entrance Wound.—In this connection, it seems proper to mention the fact that penetrating wounds of the chest may have their point of entrance almost anywhere on the body. The author has had a case of machine-gun bullet lodged in the wall of the left auricle, the entrance of which was in the deltoid muscle near its insertion into the humerus, and the track of which led through the arm, through the pectorals, between the ribs and across the thorax without causing any notable pain or discomfort. The patient walked many miles to a dressing station, was dressed there—again at a clearing station—and travelled for two days to the base where he was treated as a lightly wounded patient for a week and was to be sent back to the firing line without further ado when a slight discoloration in the axilla betrayed the course taken by the bullet and led to its detection in the heart. A small lymph gland appeared after ten days in the third costal interspace just to the left of the sternum which attained the size of a lima bean in about a month and then gradually disappeared. The man was kept in bed for this time and then gradually allowed to get up and go about his business. He had no further trouble during the next two years.

Wounds of the back of the neck, the shoulders and even the forearm may penetrate the chest without showing a secondary entrance. Wounds of the upper abdomen are often complicated by chest wounds. Wounds of the spinal column may also penetrate the chest, though, as a rule, the missile lodges in the spine. These complicated wounds are apt to lead to fatal results.

Signs of Penetration.—Hemoptysis usually occurs at the time or shortly after the wound is received and is present in about 90 per cent. of penetrating wounds. Often only a single bloody expectoration occurs, while sometimes hemoptysis continues for several days. Hemoptysis coming on after a week indicates secondary hemorrhage and is a grave sign.

Dulness at the base on the affected side may indicate hemothorax and practically always means that the pleura has been penetrated. If the dulness extends above the angle of the scapula it is probable that a pulmonary vessel has been bleeding and aspiration should not be attempted until one is sure that the clot in the cut end of the vessel is firm so that hemorrhage will not recur.

The collapse of the lung which follows, results in apical dulness,

absence of breath sounds or intense bronchial breathing. A sharp upper border of dulness the level of which is horizontal and which is surmounted by increased resonance indicates pneumohemothorax. Splashing heard when the patient breathes or moves quickly is another sign of pneumohemothorax. The coin sound is pathognomonic of pneumothorax. Bulging of the intercostal spaces and displacement of the mediastinal dulness to the opposite side may indicate intrapleural pressure and sometimes it is due to the action of gas-forming organisms.

Vesicular or heavy bronchial breathing may be heard at the base when the hemothorax compresses the lung but some function remains. The heart sounds may be transmitted with surprising clearness in a large hemothorax. The liver dulness will be low in right-sided lesions with large amounts of fluid in the chest, or when paralysis of the diaphragm exists, the liver may rise into the increased diaphragmatic arch.

Signs of compression may be present in the opposite lung indicating the condition called contralateral collapse, a condition poorly understood at present.

Pneumothorax simplex may suppress the breath sounds, alter the fremitus, increase tympany and change voice transmission.

The coin sound indicates pneumothorax, but is very difficult to obtain in most cases.

Any of these signs may be contradictory but usually no difficulty will be found in recognizing hemothorax or pneumothorax. Respiration is generally increased in rate—often up to 50 per minute and shallow. The motion of the costochondral angle is often limited and the ribs of the injured side may not function.

The Use of X-ray.—Examination with the fluoroscopic screen is more valuable than the examination of *x*-ray plates. With the screen the respiratory movements can be observed while with the plate only permanent shadows show. It is very important to know if the diaphragm is paralyzed, whether it retains its normal arch, or it is flattened or cupped and if it moves, that its excursions are equal on the two sides. Further, under the fluoroscope one can tell whether shadows represent free fluid or an organized clot. Free fluid can be seen splashing when pneumothorax exists, if the patient is moved. With any change of the patient's position the shadow maintains a horizontal upper margin, while clotted blood does not shift its borders. The free fluid can be withdrawn by aspiration while the organized clot cannot be removed except by operation.

Sometimes in hemothorax or lung collapse the mediastium may be seen to move toward the affected side during inspiration.

It is always necessary to examine the patient in the sitting position under the screen, since otherwise a small amount of the fluid being spread over a large area will not cast a shadow. In the sitting position the same amount of fluid, being concentrated at the bases, will be readily discernible.

Foreign bodies should be discovered by fluoroscopic examination and

localized as to their anatomical positions. It is well always to have *x*-ray plates taken when any foreign body is present so that the plate can be referred to as well as the skin markings. The skin markings should always be placed with the patient lying on his back, since that position can be duplicated at the time of operation. This is a very important point and disregard of it is one reason why many surgeons have great difficulty in locating a foreign body by means of skin markings.

Indications for Emergency Operations.—The most dangerous chest wound is that caused by a large fragment of bomb or shell, in which the parietes have been torn away over a large area. These wounds allow air to be sucked in and out, blood to dribble over the skin edges, where it becomes soiled and inoculated and then to be sucked back into the pleural cavity on inspiration. The edges of these blown out wounds are ragged and devitalized, often with strings of muscle and fascia hanging in shreds, discolored and dead. These wounds are attended by a grave degree of shock, insufficient aëration, and often extreme exsanguination, as immediate complications; by infection, as an intermediate complication; and by sinuses, cavities and adhesions, as late complications. The mortality in this type of wound can safely be said to be 50 per cent. at the present time, while in the early years of the great war, the mortality of these wounds seems to have been about 80 per cent. When possible, these parietal defects should be closed immediately and one often does this without anesthesia of any sort and without moving the patient from the bed in which he was first seen. In urgent cases the skin only need be sutured. This, of course, is an emergency measure and this impromptu operation is only done on patients whose condition demands an increase of aëration before they are fit for a more formal operation. One must exercise judgment and whenever possible defer operation until it can be done under more favorable circumstances so that with the benefits of anesthesia the wound can be rendered more thoroughly aseptic; the pleura cleansed of all clot and any bleeding points properly controlled so that further oozing will not produce a hemothorax. However, it is better generally to close such a wound at the earliest moment since leaving it open only tends to disseminate and make general whatever inoculation may be harbored. If subsequent effusion develops, aspiration should be carried out whenever there are signs of fluid gathering in the pleura, a sample of each tapping being cultured so that at the first sign of sepsis beginning, measures can be taken to combat it. All devitalized tissue, of course, will have been removed with scissors or scalpel at the time of closure and should an abscess form in the chest wall, it should be dealt with at once. One should attempt to close the chest wall when the lung is in its expanded stage and this expansion can be augmented if the patient will close his mouth and hold his nostrils shut with his fingers while attempting forced expiration.

Sometimes it is possible to close the chest by means of carefully applied broad adhesive bands but one must be careful while applying

adhesive that it does not limit the already insufficient respiratory movement.

Foreign bodies are not often retained in this type of wound so that sometimes the crude emergency measure just outlined will be sufficient.

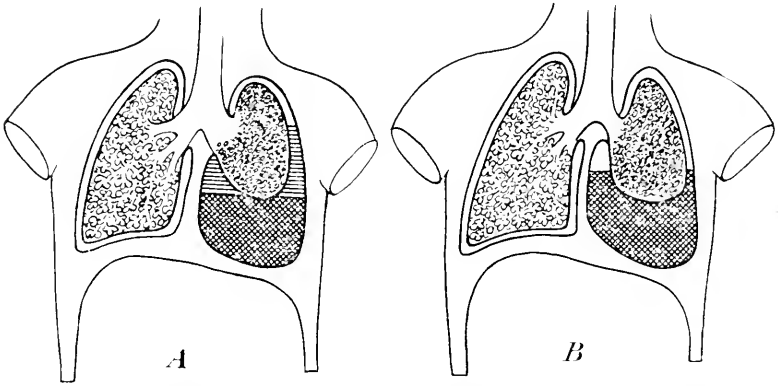


FIG. 187.—*A* shows a pleural sac partly filled with pus or blood and after adhesions have cemented the pleural layers together. These adhesions (represented by horizontal lines) prevent collapse on opening the chest; *B* shows the recent condition of the same lesion before adhesions have formed. This will allow lung collapse when the parietes are incised.

Morphin and atropin may be used to quiet the patient so that exercise and increased metabolism will not call for increased respiration. The atropin seems to be very useful in decreasing the incidence and degree of pulmonary edema. Morphin gr. $\frac{1}{6}$ is often sufficient to quiet the patient. Inhalations of oxygen are very helpful in decreasing the respiratory rate and relieving cyanosis. All these measures are directed against excitement, the waste of energy and the increased call for oxygen which results are also indirectly valuable in decreasing the heart-rate and the work thrown upon the heart muscle.

One cannot expect to save all of these patients simply because they still breathe when first seen, but nothing should be left undone which might save the most hopeless case. Practically all other wounds of the chest which need operation may be treated by a more formal procedure done under anesthesia.

Indications for More Formal Operation.—Wounds of the parietes should all be excised and sutured primarily if seen within the first twelve hours, as in this way many complications can be forestalled.

1. Punctate wounds sealed and without inflammation may be excised with local anesthesia. In this way the possibility of infection leading in from the skin is removed.

2. All superficially inflamed wounds should be excised at least down to sound tissue and the skin left open—the pleura closed.

3. All foreign bodies retained in the parietes should be removed as early as possible.

4. Open pneumothorax should be closed if possible after thorough excision of all damaged tissue.

5. Wounds with comminuted fractures of the rib should be treated by extensive excision of the bone fragments and damaged tissue and the wound closed so that open pneumothorax does not exist.

6. All infections of the pleural cavity should be operated upon at the earliest possible moment, the type of operation depending upon conditions as enumerated below.

7. Retained foreign bodies if as large as a marble and rough indicate operative removal at the earliest moment compatible with safety.

8. Continued hemorrhage from the lung or parietes should be explored and the bleeding stopped.

9. All wounds of the diaphragm or the abdominal organs should be repaired.

10. Gangrene of the lung demands resection.

Indications for Extrapleural Operation.—1. Small punctate wounds of entrance without extensive hemothorax are best treated by purely extrapleural operation, *i. e.*, excision of the skin wounds and suture if sterile or excision of the skin wounds without suture if inflamed. Small amounts of sterile fluid when present should be aspirated through uninjured skin at the time of operation or before.

2. Bullets and shrapnel balls imbedded in the lung or free in the pleural cavity unless other indications coexist, *e. g.*, large clotted sterile hemothorax or infected hemothorax, should not be followed through the pleura. Rough pieces of metal or clothing should always be removed.

Indications for Non-operative Treatment.—(1) Profound shock. (2) Cases of dry entrance and exit bullet wound seen for the first time after three days and without signs of pleural infection. One can gain nothing by excising these old wounds in which primary healing has already begun. (3) If the weather has been extraordinarily fine and dry and the patient has been in an exceedingly cleanly condition when wounded and the wound has been made by a bullet or shrapnel ball, there being very little hemothorax, operation may be omitted with comparative safety—for example, bullet wounds of the chest received in the deserts of Palestine and Mesopotamia were very seldom infected. The same holds true of wounds at sea, in mineral mines and often among the higher classes of the population who bathe regularly.

Anesthesia.—The past few years have demonstrated that while the various cabinet arrangements for anesthetizing chest cases are fine in theory, they are unnecessary in the vast majority of cases. They were not used to any extent by army surgeons during the great war.

The best anesthesia in the simple resection of a rib for drainage is local anesthesia combined with the previous administration of morphin gr. $\frac{1}{4}$ and atropin gr. $\frac{1}{100}$. Infiltration is made with 1 per cent. novocain in a linear fashion intradermally in the line of incision. Fol-

lowing this, injection of the intercostal nerve above, intermediate and below the proposed incision is done, so that two ribs can be removed instead of one if found advisable. The intercostal nerve is best reached by piercing the skin at the posterior edge of the linear skin injection and feeling for the lower border of the rib. The nerve will be found just inside the lower border lying between the intercostal muscles. Sometimes it is quite near the pleural side of the rib, so that care must be taken that the needle does not go through and pierce the pleura thus making the injection into the pleural cavity and not about the nerve. If the injection is made midway between the ribs the anesthetic will not reach the nerve and the result will be unsatisfactory. An abundance of the novocain solution should be used.

After the nerve has been injected, it is wise to pierce the periosteum on the outer surface of the rib at about its middle and make a subperiosteal injection of novocain. If one succeeds in making these three injections perfectly, the pleural cavity may be opened without pain. The subperiosteal injection often causes a slight stinging of which the patient may complain. If the work to be done on the chest wall is very extensive, it will be advisable to inject 5 or 6 or more nerves at their point of exit from the spine. After the rib has been resected, it may be necessary to inject the parietal pleura before making the incision into the pleural cavity but this necessity only arises when the intercostal nerves have not been blocked. The normal visceral surface of the pleura is practically anesthetic, particularly the pleural surface of the lung, which can be handled, incised or sutured painlessly.

One of the great advantages of using local anesthesia is that the lung may be inflated by the patient's holding his nose and blowing when air from the sound side of the chest is transmitted to the opposite lung which is thus expanded to fill its pleural cavity. When one is ready to close the wound, the patient is simply asked to do this, and while the lung is held in expansion, the sutures, which have been already placed, are tied. A further advantage of local anesthesia is that no mucus or secretions are aspirated into the lung which in its injured condition is particularly susceptible to infection and postoperative pneumonia.

A still further advantage is that the patient can move himself about so that the operator gains the advantage of having the patient's position changed to suit his purposes. This is often of very real advantage when one desires to empty out a very extensive hemothorax.

Next to local anesthesia, nitrous oxide and oxygen is best. It enables one to inflate the lung by using a positive pressure and the anesthesia can be regulated more quickly than is the case with ether or chloroform. The ease with which oxygen can be administered is a very important point since the cyanosis which these patients show is often very alarming but can be controlled nicely by the gas-oxygen method. Even though both sides of the chest are open anesthesia can be continued by alternately increasing and decreasing the pressure

which causes the lung to expand or deflate independently of the natural respiratory effort. In fact anesthesia can be maintained by simple inflation, the gaseous interchange following the laws of diffusion. This is a decided advantage when it is necessary to have the patient lying on the uninjured side of the chest, as both lungs can be used for respiration and anesthesia with this method.

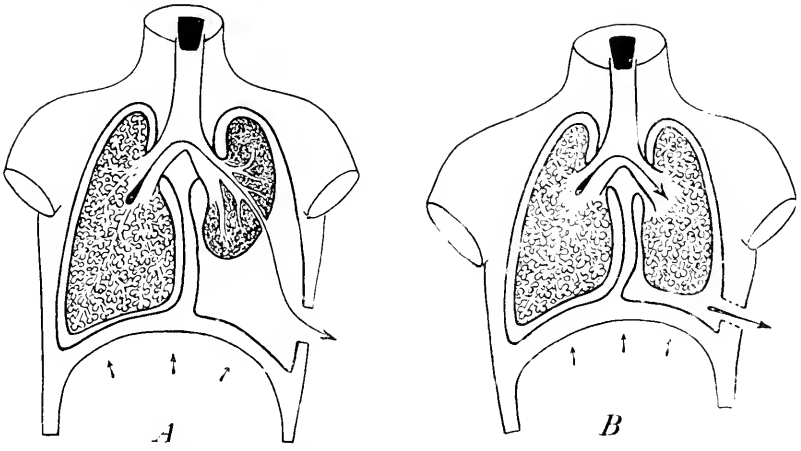


FIG. 188.—*A* shows the futility of attempting to inflate a punctured lung by any means; *B* shows the method of inflating a collapsed lung by forced expiration—the nostrils and mouth being held shut, as can be done under local anesthesia. The parietal defect can be closed at this time leaving an inflated lung.

Ether anesthesia may be employed but chloroform seems preferable in lung cases where gas-oxygen or local anesthesia cannot be used as there is not so much irritation to the lung tissue itself and post-operative pneumonia seems not to follow so often.

Spinal anesthesia is definitely contra-indicated whenever pneumothorax exists or may occur during the operation.

Conservative Treatment.—There can be no doubt that whenever possible non-operative treatment gives the best results. While the large majority of chest cases should be treated in this way, one must realize of course that a certain number demand operation as a life-saving measure and still a larger number require operation that their convalescence may be shortened and their risks be lessened.

Patients without especial damage to the thoracic wall, whose wounds do not admit air or have been sealed, who show only slight elevation of temperature, whose pulse is under 100, whose apex beat is not displaced, who have no cough or pain, will not as a rule need operation. Those who have had simply a penetrating wound with an infinitesimal pneumothorax, whose lung has not been collapsed will need little more attention than rest in bed for a few weeks followed by breathing exercises before resumption of duties. These cases do not often show any ill effects from their wound. The type of case which resembles

the one already mentioned but has in addition the fracture of a rib or an extensive hemothorax, will require a firm adhesive strapping around the whole chest (both sides) to immobilize this fracture and free the patient from pain, and aspiration of the hemothorax should be undertaken before it begins to organize.

It makes little difference whether pneumothorax occurs with hemothorax or not, except that with pneumothorax the injured lung more frequently collapses and for this reason more difficulty is experienced in getting the lung to expand normally again. Some of these patients several years after receiving their wound, complain of pain and dyspnea on exertion. They often show the physical signs of thickened pleura after a few years, and one finds that many of them have lungs firmly bound by pleural adhesions.

These patients should have the fluid withdrawn on about the third day. If intense coughing or fainting occurs the aspiration should be discontinued and repeated on the next day. It is often possible to withdraw as much as three pints of bloody fluid from a chest at one sitting without causing cough, dyspnea, pain or faintness. It often happens that only a small amount can be withdrawn at the first attempt and that an equal or greater amount may be withdrawn next day. At all events it is not advisable to leave large amounts of blood in the pleural cavity until organization occurs.

The following dangers and precautions should not be forgotten in aspiration:

The expansion of the lung which follows may dislodge the clot, which has been plugging a torn vessel and the hemorrhage may recur. For this reason, it is wise to wait forty-eight hours before aspirating so that the clot may become firmly attached and there will be little danger of this accident.

There is the danger of infecting a sterile hemothorax but in the author's experience this never occurs, if proper precautions are always taken.

It is wise to use a very large needle when aspirating as a small needle readily becomes plugged. It is very important to make the vacuum in the suction bottle one's self as we have seen two cases in which the bottle had been carelessly pumped full of air under great pressure and this air had been injected into the pleural cavity. It is always well to test the apparatus by placing the needle in sterile water immediately before using it.

If the patient is a nervous individual, it is well to make a local infiltration before inserting the large needle. The puncture should generally be made in the eighth space in the posterior axillary line unless the hemothorax seems to be circumscribed which is rare if seen early.

These patients should be treated in the sitting position and should not be transported for at least a week if possible. There may be fever as high as 101° due to the absorption of hemothorax without any active infection, so that one cannot definitely determine infection by the temperature alone unless it be very marked. It is wise to take a culture

from every aspiration so that one can anticipate or diagnose the presence of a septic involvement.

Streptococcus Infections.—When sepsis occurs, any of the pus-forming organisms or the anaërobic organisms and hemolytic streptococcus may be present. The hemolytic coccus is most to be feared and cases developing sepsis with this organism have a very serious prognosis. They demand radical resection of two ribs, complete washing out of pleural cavity and drainage from the most dependent part. It is well in this type of case to use from 3 to 6 Carrel's tubes reaching into every crevice and corner of the pleura and in very severe cases, even introducing three to six or more of Carrel's tubes through an intercostal incision between the upper ribs in front, so that the solution may trickle over the entire pleural surface. The same procedure should be adopted when the gas-forming organisms are discovered. The odor from infection with these organisms is very characteristic and foul and the fluid which one finds is thin, reddish-brown in color and serous rather than purulent.

When a hemothorax becomes infected with ordinary pus-forming organisms drainage should be instituted in the usual manner, resecting one or two ribs in the midaxillary line. Every effort should be directed toward the rapid elimination of infection so that early secondary closure can be done. In this way large cavities may be obliterated by an expanding lung, whereas if drainage had been prolonged with the resultant thickening of the pleura and pulmonary adhesions, healing would have been very slow.

Posture.—If one were asked to name one single prescription for the treatment of penetrating wounds of the chest which was better than the rest, one should say that the sitting posture is that treatment, since every case should be placed in that position unless shock is too severe. In such a condition one should elevate the head of the bed while the patient lies flat, and raise him to a sitting position at the earliest possible opportunity. In fact, the sitting position should be attempted at once in every case and if the patient faints (as those in extreme shock may do) he should be allowed to lie back again. It may seem that this experiment should be avoided by some mysterious diagnostic maneuver, but as a matter of fact while one can sometimes see at a glance that an apparently moribund patient would be harmed by the slightest movement, in general it is difficult to say that even the most hopeless case will not be benefited by the sitting position. This is explained by the fact that this posture allows the venous blood to drain away from the lungs, so that congestion there is decreased. When this is accomplished the resistance to the flow of arterial blood through the lungs is diminished and the heart has less work to do and consequently the general circulation improves.

Further than this, the sitting position allows the diaphragm to functionate better and frees the ribs which are compressed when the patient lies on either side. When the patient lies down flat he has a tendency to lie on the uninjured side and thus compress the side upon which the

burden of respiration falls—the injured lung generally being allowed to rest in part, or completely as in open pneumothorax.

Another benefit gained by the sitting posture is the lessened tendency for hemorrhage to occur from the wound of the lung. Just as congestion increases the work of the heart, so it increases the pressure in the vessels of the lung and therefore hemorrhage may occur whereas it would have been avoided had the pressure in the pulmonary vessels been less. As a matter of fact a patient who is first seen with the thready, rapid pulse of hemorrhage, sometimes regains a full pulse in a very short time after he sits up in bed; and concomitantly the hemorrhage ceases. The author has seen hemorrhage from the lung occur within five minutes after a patient who had been left in the sitting posture had assumed the supine position. This case was an exceptional one—a conscientious objector, who not only objected to fighting but also objected to medicine, surgery, hospitals, religion, the government and his meals—and the flat position was his own idea. He would assume it whenever the opportunity presented—not because he thought it good for himself, but because nobody wanted him to do it. He died of hemorrhage and general septic pleurisy. As a universal rule the patient who has been raised to the sitting position will stay in that position because he is then most comfortable. The respirations become easier, slower, the expression changes from an anxious Hippocratic one—often with cyanosis—to a more contented type, and often to a cheerful one. If great care is used in the first days the skin over the sacrum becomes harder and bed-sores are unlikely to develop.

When there is infection in the pleural cavity this position prevents its spread to the entire cavity and tends to localize it to the lower margins.

When there is drainage of the pleura this position favors thoroughness since then the tubes can be placed at the actual bottom of the cavity and pocketing cannot occur.

Thus the sitting posture provides: (1) against spread of infection; (2) for drainage of the pleura; (3) a guard against hemorrhage; (4) comfort; (5) relief of dyspnea; (6) relief of cardiac overloading.

However, since no rule in medicine is without exception, one will infrequently see a case where the foot of the bed may be elevated with apparent benefit. Thus when the circulatory distress is very great as after exsanguination and after the bleeding has definitely ceased, raising the foot of the bed seems to benefit the failing circulation.

Transfusion.—It is far better to treat these cases with transfusion of blood, however, with ligature of the bleeding point at once. Transfusion can be done, gas and oxygen anesthesia given, and ligature done with as much wound toilet as possible in passing and the patient emerge in considerably better shape than beforehand. It is often advisable to give the transfusion in two parts, the latter half being given after the operative maneuvers are complete so that the new blood is not lost through hemorrhage. At least 800 c.c. of blood should be given.

General Type of Intrathoracic Operation.—The skin is scrubbed with soap and water, dried thoroughly with alcohol or benzine and painted with tincture of iodine. The usual asepsis must be strictly carried out and further than this, when entering the chest through a dirty lacerated wound of the parietes, it is well to make a complete change of instruments, gloves and linen after the parietal wound has been rendered aseptic by the careful excision of all damaged tissue, followed by disinfection with some antiseptic such as tincture of iodine, alcohol, picric acid or the like. Some prefer to rub the edge of the cleansed wound with bismuth iodoform paraffin paste.

When the operation is one for removing a foreign body and evacuation of a hemothorax, it is well to be guided as to the site of incision by the location of the foreign body, bearing in mind the fact that entrance through the fourth or fifth space gives access to the entire lung including the hilus. When incision is made through sound tissue without regard to the wound of entrance, it is well to reserve excision of the entrance wound until the chest has been closed again, so that any possible surface contamination near the entrance wound cannot be implanted within the pleura. No matter by which route it is decided to enter the chest advantage should be taken of a large incision, at least six inches long through the skin with removal of four inches of the rib, since one can close the chest easily if this is done. The intercostal muscles above and below give good anchorage to sutures.

Having opened the chest, whatever hemothorax is present should be emptied by allowing the fluid to be splashed out by the respiratory movements or swabbed out with large dry pads. Clots may be scooped out with the hand. If the operation is done under local anesthesia one enjoys the coöperation of the patient who rolls himself so that the wound is dependent, but when general anesthesia is used, it is sometimes difficult to turn the patient without causing a serious fall of bloodpressure as has been shown by Major Shattuck and Captain Blair.[1]

Any large clots or deposits of fibrin should be cleaned out at this time. It is wise to palpate thoroughly every clot for if one does this as a routine he will sometimes find that a foreign body which was apparently buried in the lung was really free in the pleural cavity and has been swabbed out with the hemothorax. Thus one may be saved a long search for a foreign body which has already been recovered, the patient will be saved the consequent shock and the surgeon much embarrassment.

The next step is to retract the ribs widely and inspect the interior of the thorax—next the hand may be passed into the chest and the lung palpated. Large foreign bodies are readily felt in the lung by grasping it between the thumb and fingers and also large rents in the visceral pleura may be felt. However, the small wound made by bullets may easily pass unseen and unfelt. When the foreign body is

[1] Blair, R. B. and Shattuck, G. C.: Penetrating Wounds of the Chest, Jour. of the R. A. M. C., September, 1918.

located, the lung is grasped firmly and held with a piece of gauze to prevent slipping and a small incision made directly down to the foreign body which is then squeezed out through the opening. Any large tears may be repaired quickly by passing a catgut stitch through it, using a large round needle.

Gangrene of Lung.—If there is hemorrhage from the lung the same procedure is adopted but one must be careful not to include too large a piece of tissue in one ligature or else peripheral gangrene may occur and thus set up a focus of infection. If gangrene is already present, resection of the gangrenous area must be done. It is best to pass a series of figure-of-eight stitches above the gangrene. These are tied and then the gangrenous portion is cut away with scissors or scalpel.

WOUNDS OF THE DIAPHRAGM.

If the diaphragm is ruptured, it must be repaired and this is easily done by direct suture from above. Foreign bodies may be removed from the liver by transpleural and transdiaphragmatic incision quite readily. The liver can also be nicely drained by the transdiaphragmatic route in which case the diaphragm is sutured to the parietal pleura at a level higher than the parietal incision. If necessary a strip of the diaphragm may be removed from its lateral attachment and attached to a higher level, and, by using this principle, it is sometimes possible to repair actual defects in the diaphragm. The pleural cavity should always be shut off from the abdominal cavity. Transdiaphragmatic wounds of the hollow viscera should be attended to either by the transdiaphragmatic route or by abdominal section if they cannot be reached through the diaphragm.

Closure.—Whenever possible the chest wall should be closed tightly. The one notable exception to this rule is the presence of streptococcic infection, when radical drainage must be provided. It is well to secure ample drainage when the gas-forming organisms are present. Whenever there is doubt as to whether the chest should be closed or not, closure should be attempted as the postoperative recovery is much easier with a closed chest. If the temperature and pulse-rate rise, the chest may be reopened by simply removing the sutures at any time. In this connection it is advantageous to have the incision as near as possible to the bottom of the pleural cavity since if the wound must be reopened it will drain better from the lowest possible point. When a wound has been reopened Carrel's tubes may be placed within it and irrigated at frequent intervals. If the patient's condition permits, he should be made to take breathing exercises, the salient point of which is that forced expiration against resistance be employed so that the collapsed lung will be made to inflate by the pressure developed in the sound lung on expiration. For this purpose Wolff's bottles or breathing tubes are very valuable. If breathing exercises are disregarded at this period, fibrosis of the lung and large pleural cavity formation will most likely result. Another point about closing all

doubtful cases is that in the short periods during which the cavity has been closed, fibrinous adhesions will be formed between the visceral and the parietal pleura, and these adhesions will help to hold the lung in its expanded condition. This makes for good function and early healing by granulation since a smaller cavity remains. The use of various valve apparatus has not been generally thought satisfactory, due to the difficulty in making an air-tight junction between the wound and the mechanism.

Whenever it is necessary to drain the pleura, time will be saved and the unfortunate results minimized, if half measures are discarded. One should not hesitate to resect two ribs if by doing so freer drainage is established. Tubes of large diameter should be used for drainage purposes and should be kept free by daily irrigation with some warm mild antiseptic solution such as Dakin's. When using Dakin's solution, it is well to have the solution made double strength and to dilute with an equal volume of warm water immediately before irrigation, as in this way the chlorine which it contains is not volatilized and lost.

Postoperative Care.—The diet should be a fluid one for the first twenty-four hours, including water, tea and warm milk with eggs.

Rectal saline is of benefit, and in case of severe shock blood transfusion is of great value, from 400 to 800 c.c. of blood being transfused. Intravenous infusion or hypodermoclysis of normal salt solution may be done if transfusion cannot be accomplished. It is not advisable to give intravenous infusions of sodium bicarbonate and glucose solution as this solution in excess produces pulmonary edema.

It is important to keep the patient quiet after operation. For this purpose morphin and atropin may be given freely during the first day unless the patient shows the peculiar gray color which indicates a condition in which morphin is contra-indicated. Morphin may be used when ordinary cyanosis is present.

These cases should not be transported any distance either before or after operation.

A specimen of the fluid which accumulates after operation should be obtained twenty-four hours afterward and cultured. If a large amount of fluid accumulates, it should be withdrawn and it may be necessary to repeat the aspiration for several days. When the culture shows hemolytic streptococcus secondary drainage should be established at once. Or, if low grade sepsis ensues and aspiration gives only momentary relief, secondary drainage should be secured.

Sometimes aspiration repeated daily and combined with aspiration-irrigation, as recommended by Major George Shattuck of the Harvard Unit, is sufficient to combat a low grade infection. Aspiration-irrigation is done by alternately emptying and filling the chest with Ensol solution using the aspiration apparatus.

When the chest is open and draining and when the lung is not held fast by pleural adhesions, it is well to arrange the dressing so that as little air enters and leaves the cavity as is possible. Much can be accomplished by using jaconet or oiled silk for this purpose. When

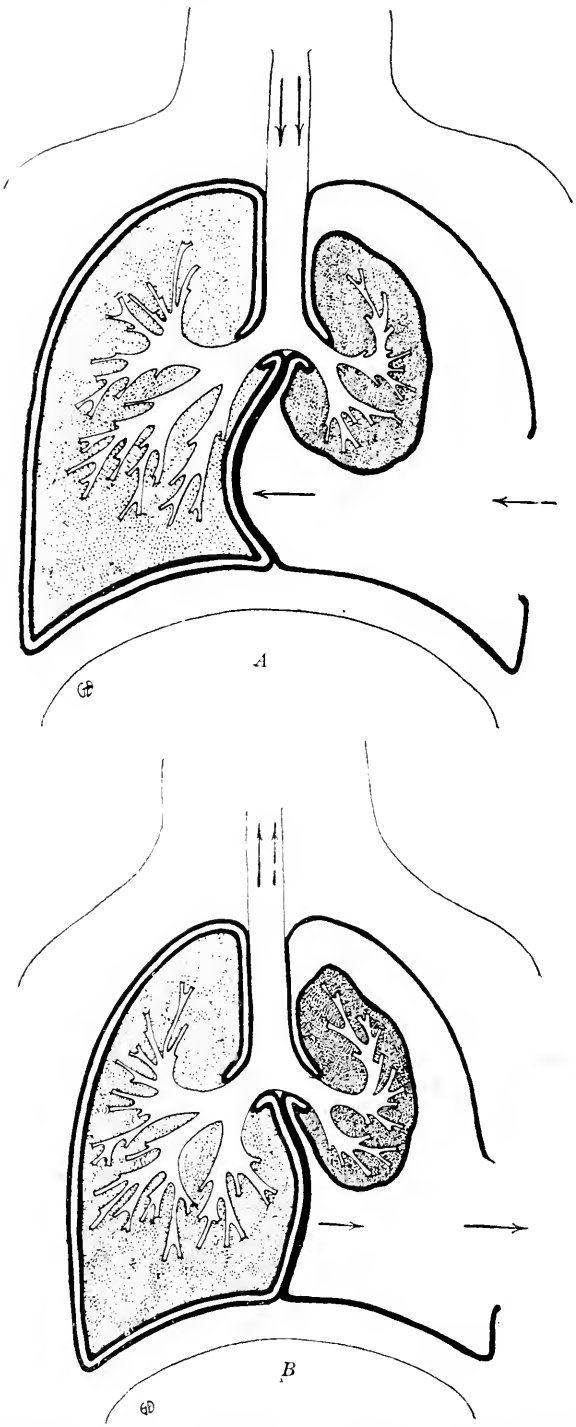


FIG. 189.—Note bulging of mediastinum. *A*, position of the mediastinum during inspiration when a large parietal defect is present. *B*, position during expiration. The mediastinal excursion is not great when the parietal defect is small.

the lung is adherent to the parietal surface and walls off the septic cavity, open drainage can be used. This is an advantage in closing the chest primarily, *i. e.*, adhesions form so that secondary drainage does not result in lung collapse.

Late Treatment. — Old empyema cavities can be obliterated by collapsing the parietes. This crude procedure is seldom necessary if the early treatment has been correct. Foreign bodies whenever they cause inconvenience, pain, dyspnea or mental discomfort to the patient may be removed. Accurate *x*-ray localization should be demanded before the attempt is made.

Beck's paste is valuable in clearing up cavities, but careful watch must be maintained that bismuth poisoning does not occur.

SURGERY OF THE HEART AND PERICARDIUM.

By HARRY M. SHERMAN, A.M., M.D.

THE HEART.

The surgery of the heart must include lesions originating in that organ, but its relation to the precardium, pleura and lungs is such that these parts must participate in the lesion or in its surgical repair, so that a complex of lesser or greater extent is the final stage.

For surgical considerations the heart lies behind the middle of the sternum, the inner ends of the right third, fourth and fifth costal cartilages, and all but the outer ends of the left third, fourth and fifth costal cartilages. Its association with the chest wall, the pleura, the lungs and the pericardium are shown (Fig. 190) in the composite illustration.[1] The precordial space (after Testut) is included within a line which begins "on the upper border of the third right costal cartilage, 1 cm. from the right border of the sternum;" it extends, with a slight convexity to the right, to a point "on the level of the sternal articulation of the fifth right costal cartilage," thence it passes, with a slight convexity downward, to a "point at the apex of the heart, a location easily made out in the living. On the cadaver it is placed on the upper border of the fifth left costal cartilage 8 cm. from the midsternal line." Hence the bounding line passes upward, with a slight convexity to the left, to a "point in the second left intercostal space, midway between the cartilages above and below, and 2 cm. to the left of the left sternal border." The pericardium has a somewhat triangular projection on the chest wall: the base line commences at the right, 2 cm. from the right sternal border in the middle of the fourth space, and passes, slightly curved downward, cutting the top of the xiphoid, to the left and terminates 6 cm. to 8 cm. from the left sternal border in the fifth space. The pericardial limit on the right side, slightly convex to the right, begins at the right end of the base line and passes upward, 1 cm. to 2 cm. from the border of the sternum, to the second cartilage, then it approaches and passes beneath the sternum. The pericardial limit on the left begins at the left end of the base line, and passes obliquely upward toward a point which ought to be a little outside the left sternoclavicular articulation.

On these projections lie, on either side, the lungs and the two pleuræ.

[1] Terrier et Reymond: Chirurgie du Cœur et du Pericarde, Paris, 1898.

The two pleural sacs lie in front of the pericardium and behind the left half of the sternum from the second to the fourth costal cartilage. The borders are parallel and 1 cm. to 2 cm. apart. At the fourth cartilage they both swing outward, the right so that it crosses to and runs along the seventh cartilage, the left more sharply, so that it crosses both sixth and seventh cartilages about their middles. Inside of the pleura the anterior borders of the lungs reach nearly to the same limits, except that the left lung, at the fourth cartilage, swings outward to the outer part of the fifth and then inward to the middle of the sixth cartilage, making the cardiac notch. Within this space the heart has in front of it only the pericardium, the pleuræ and the structures of the chest

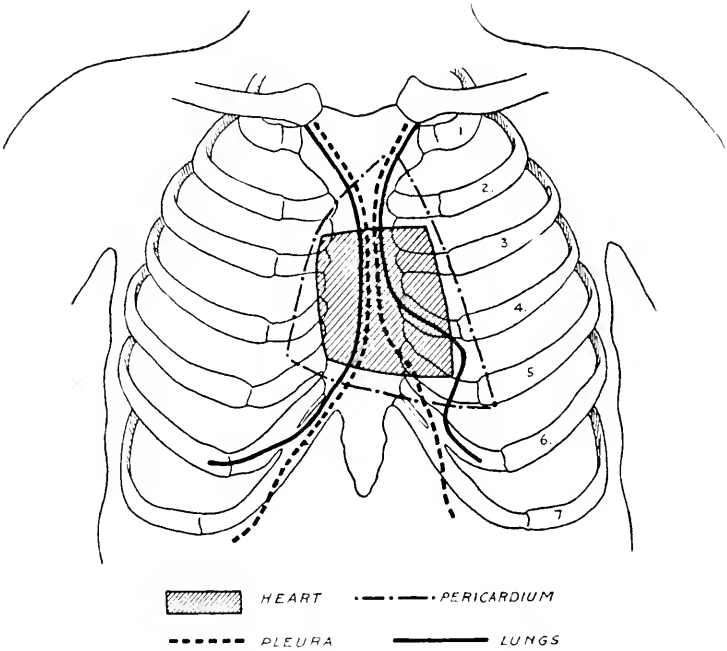


FIG. 190.—Composite illustration, showing outlines on chest wall of the pleuræ, lungs and pericardium. (Terrier et Reymond.)

wall. It follows that the pericardium or heart can be reached from the outside without wound of either pleuræ or lungs, as at the inner end of the sixth space. Over a larger space, as over part of the fifth and nearly all of the fourth intercartilaginous space, the pericardium and heart may be reached through the left pleura but without wounding the lung. For the rest, unless the wound be by a missile which penetrates the sternum, the approach to the heart, from the outside, necessitates wounds of both the pleura and lung of one side.

The lesions which may demand surgical intervention on the heart are, potentially, some medical conditions and actually, certain traumata.

The medical conditions are pure mitral stenosis, certain aortic stenoses and some stenoses of the pulmonary artery.

"Pure mitral stenosis is a lesion limited to the valves, the cardiac muscle remaining long unaffected as well as the peripheral circulation. The free border of the valve is alone affected, the valves themselves remaining soft and supple." It is the lesion which attracted Brunton and led him to observe that "incision of the stricture could remove the obstacle which had formed the sole barrier to a normal circulation."

Aortic stenosis, not of either the supra-aortic nor of the subaortic varieties, but pure "valvular stenosis, characterized by adhesions between the free borders of the valves, with thickening and deformation of their margins" may be considered truly a surgical variety. And stenosis of the pulmonary artery, of the same valvular type, when "the fibrous arc of insertion is intact, and the welding of the valvular margins creates a sort of diaphragm, convex toward the pulmonary artery, the more or less narrow central orifice of which is susceptible of enlargement. . . . There may be pure stenosis of the pulmonary orifice in young subjects without any alteration of the myocardium or congenital malformation of any other orifice. This condition is one eminently favorable for mechanical treatment."[1]

All of these lesions with the primary pathological process limited to the valves, and with the cardiac muscle unaffected except by a compensatory hypertrophy, both of which conditions may continue for a long time without danger to health or life, may be found to lend themselves to adroit surgery, but the mere existence of the complex does not call for help immediately nor without consideration, because of their possible long continuance. "The lesion which tends to provoke grave or fatal trouble in the near future is the genuine indication that points to the adoption of surgical measures which can change such an ominous state into a relatively benign insufficieney." If this was found on trial to be an improvement it is impossible to avoid the question as to the permanence of the gain, and equally impossible to answer the question without the trial. That the trial will some day be made is a safe propheey.

A surgical procedure upon the heart may be attempted with the heart in action, but it can best be done with the flow of blood through the heart stopped and with the heart at rest. This condition can be attained by clamping the great vessels of the pedicle of the heart. Through an ample incision in the pericardium one blade of a Doyen clamp, rubber sheathed, is slipped in behind the great vessels from right to left, the other blade being outside the pericardium; this clamp when closed can completely control the circulation through the heart and may be kept in place for from two to two and a half minutes without harm, provided the respiration has been kept up by a positive pressure apparatus and that the blood has been overaërated just prior to the closure of the clamp. While the clamp is in place the heart may show slight pulsations or may be perfectly quiet.

Compression of individual vessels or of combinations has effects

[1] Quoted from Carrel and Tuffier: Med. Press and Circ., 1914, xcvii, 539, 566.

which vary with the vessels selected. Compression of the pulmonary artery and aorta alone can be maintained for but a very short time because of the great dilatation of the right heart. Partial closure of the vessels continued for ten minutes produced no bad effect on the animal and the aorta has been ligated for a period of six minutes without resulting harm. "Simultaneous compression of the pulmonary veins produces death after some minutes through default of oxygenation of the cardiac muscle." "Of all the procedures of cardiac hemostasis . . . that which is best is the compression of both venæ cavæ. The blood within the caval veins no longer flows into the right auricle and right ventricle; the intracardiac circulation is arrested, but not the coronary circulation. The latter continues for some time"[1] and the coronary arteries have been seen to beat, the blood already in the lungs continuing to return through the pulmonary vein into the left heart and thence passing into the general circulation. Caval closure must not exceed three and a half minutes on account of the danger to the cerebral circulation, but oxygenated Ringer's solution may be injected into the carotids and so reach the brain, and this permits the time of closure to be extended to ten minutes. "With regard to the arrest of the circulation in the substance of the cardiac wall, that is to say, the arrest of the coronary circulation, this cannot be prolonged beyond one or two minutes. Oxygenation is absolutely necessary for maintenance of the cardiac irritability, and accordingly the occurrence of congestion is extremely dangerous."[2]

In planning or executing a surgical act upon the heart there are certain regions which must be avoided as being danger zones. These are regions of coronary distribution, for the coronaries are terminal arteries. Accidental section or ligation results in fibrillary contractions and death if the vessel be a large one, or of degenerative changes in the muscle if the vessel be smaller. Therefore, "the part of their course which extends from their origin to their earliest divisions represent an area of *noli me tangere*. The septum interauriculare is a structure of extreme sensibility on the slightest contact with which the heart stops in diastole. Section of the auriculoventricular border provokes immediate arrest of the left ventricle in diastole; the respiration nevertheless undergoes no modification, and the auricles and right ventricle continue to beat. At the level of the septum auriculoventriculare there is a definite locus, the point of Kronecker and Schmey, a wound of which provokes immediate arrest of the heart." And there is a point, "situated in the auriculoventricular region near the left margin of the heart . . . of which a wound is dangerous and even fatal, even a slight pressure over this part provokes an extrasystole."

"On the other hand, there is a point situated in the anterior longitudinal groove, at the junction of the middle and upper thirds, of which the mechanical irritation may determine a brusque arrest of the heart."

The base of the right auricle must be regarded with respect as an

[1] Loc. cit. [2] Loc. cit.

especially important center, the Kieth-Flack or sinus node is situated in the angle formed by the junction of the superior cava with the right auricular appendix. It has been established that from this node arises the impulse which causes the heart to beat. Thus, section of the base of the right auricle, if it involves this center may cause death, while the left auricle which is free from such specific mechanisms, appears to tolerate every section with impunity. . . . .

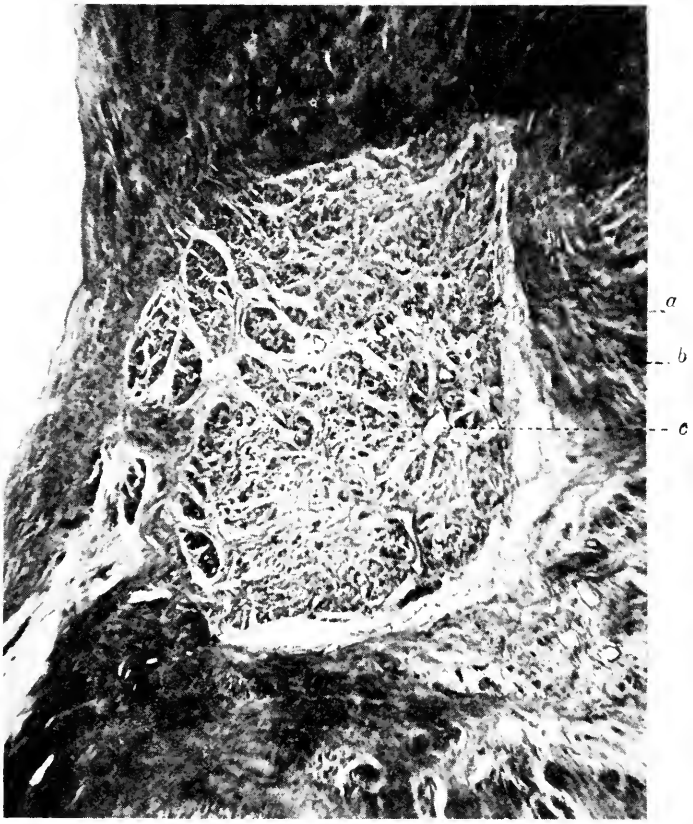


FIG. 191.—A transverse section through the distal portion of the normal His bundle at a point in its passage through the auriculoventricular fibrous ring. *a*, bundle fibers; *b*, fibrous connective tissue surrounding the bundle; *c*, bundle vessels. (F. Nuzum.)[1]

We are also concerned with the auriculoventricular conducting system which conveys the cardiac impulse from the sinus node to the individual muscle fibers of the myocardium. The stimulus passes from the sinus node, a structure 20 to 25 mm. long to 1 to 2 mm. in diameter, to the muscle fibers of the right auricle and is conveyed by these fibers to the Tawara node at the base of the interauricular

[1] Arch. Int. Med., 1914, xiii, 640.

septum. The His bundle (Fig. 191) is the continuation of the Tawara node and passing from the interauricular septum, through the central fibrous body and into the interventricular septum, it constitutes the only muscular connection between the auricles and ventricles. The His bundle in its distal portion, which is just beneath the undefended space of the interventricular septum, divides into right and left branches that pass downward beneath the endocardium of the interventricular septum. At the apices of the ventricles these main branches

FIG. 192.—Adipose tissue in the His bundle. *a*, central fibrous body surrounding the bundle; *b*, intact bundle fibers; *c*, adipose tissue; *d*, bundle vessels. (F. Nuzum.)

of the His bundle subdivide many times and continue as the Purkinje fibers to the muscle cells in the ventricular walls and papillary muscles with which they fuse. Lesions of this auriculoventricular conducting system are responsible for many of the cardiac irregularities. Among such lesions are fibrous or degenerative changes, inflammatory or fatty (Fig. 192) infiltrations, gummata and pressure on the bundle by fibrous nodules or other tumors in neighboring structures. A blocking of the passage of the cardiac impulse from the auricles to the

ventricles may result. A type of irregularity known as heart block is then established in which the auricles and ventricles beat independently of each other.

"Finally, the endocardium is much more sensitive than the other cardiac tissues, doubtless through the influence of the subendocardial nerve plexus."[1]

In other regions of the heart the walls may be cut, or a portion may be resected and after suture, healing occurs, but it is by subepicardial and intermuscular fibrous tissue and not by muscle regeneration. Transplantations may be done but can only be of very doubtful value. Inside the heart, "although the endocardium is sensitive the valves can be divided, detached, ligatured or fixed. The orifices of the great vessels are surrounded by arteries and nerve branches which must be taken care of. Knowing the position of the coronary arteries at their origin, we can attack the anterior aspect of the base of the aorta without fear of wounding them. The walls of the great vessels, especially those of the aorta, are very friable, so that a secondary gaping of the line of suture is possible; accordingly, it is necessary to reinforce with a layer of transplanted fascia or . . . with a segment from the wall of a vein."[2]

The procedures called for in the conditions previously mentioned are all of them to enlarge stenotic orifices when the stenosis is due to lesions of the valves alone. Section of the adherent valves, valvulotomy may be done by internal or external methods or by grafting on a new path from cavity to cavity around the stricture. Internal valvulotomy, belongs to the period of experimentation pure and simple, done, as it is, in the dark by a long instrument with a sheathed knife passsed into one of the vessels of the neck. The total inaccuracy of the maneuver must forbid its use on a human being. Vessel grafting, to offer the blood a detour around the stricture, is a more direct method. Lengths of any large vein may be used, the patient's own saphenous vein would be appropriate, and valves must be in the piece and so disposed as to permit the blood to pass only in the direction desired. If no valves chance to exist a valvular action can be gotten by making a slight intussusception and fixing it with a little suture. Such a length of vein may be placed so as to offer a detour around the pulmonary valve, from the right ventricle to the pulmonary artery, or around the mitral valve from the left auricle to the left ventricle, or around the aortic valves, from the left ventricle to the brachiocephalic trunk. These maneuvers again are so complex and depend on such inconstant factors that they, too, must be thought of as being experimental matters only.

External valvulotomy is based on the principle of incising the valve from without inward and also permitting an increase in the size of the orifice; the operation divides "the border of the aortic orifice and the valve at the same time. This direct section of the valve should be carried out with precision, on account of the fact that the cardiac zone,

[1] Carrel and Tuffier: Loc. cit. [2] Ibid.

which surrounds the origins of the aorta and pulmonary artery, is specially sensitive and very readily originates reflex movements. We should keep as far as possible from the vicinity of the coronary arteries; those vessels arise, however, in positions sufficiently far apart to enable us to pass readily between them on the anterior aspect of the aorta."[1]

"The operation consisted in suturing on to the surface of the . . . artery a patch of vein preserved in cold storage and in cutting the edge of the orifice underneath the patch . . . A piece of vena cava or of any other vein . . . is cut into the shape of a rectangular flap about 2.5 cm. by 2 cm. This flap is put on the anterior part of the . . . artery in such a way that its middle corresponds about to the pulmonary orifice, the lower part being on the surface of the ventricular wall. Then the two lateral sides and the upper side are fixed to the surface of the heart and the pulmonary artery by means of a continuous suture. The longer blade of a special pair of scissors with a longer sharp pointed and a shorter blade, are "introduced beneath the lower side of the flap and the sharp point is introduced into the lumen of the pulmonary orifice. Then the wall is cut and dark blood escapes between the surface of the heart and the lower part of the flap, but the hemorrhage is immediately controlled by the index finger of the operator which presses the flap down on the wound. The fourth side of the flap is next fixed to the surface of the heart by a continuous suture."[2]

The flap immediately is lifted up and stretched by the pressure of the blood, but it has lived with its inner side in contact with the blood and its outer with the pericardium, nor does thrombosis take place, as the flap is lined with endothelium.

This operation may be done without stopping the circulation through the heart; but it should be more easily done, and within the sight of the operator, by clamping the pedicle of the heart and stopping the circulation for a very short time. Under this method a valve has been sectioned and then immediately resutured, or two contiguous valves have been sutured together, or the border of a valve has been cauterized, and then the wound has been closed and the action of the heart has been resumed.

Entrance of air into heart cavities necessarily occurs if they are opened under cessation of the circulation. If this is in the right heart no harm comes, air emboli in the branches of the pulmonary artery causing no trouble. If the left heart has been opened and air has entered it must be taken out by aspiration as the sutures are tied to prevent its entering the coronary arteries, for it here obstructs the flow of blood and fibrillary contraction ensues with a fatal outcome. In some instances it has been possible to puncture the artery with a needle and let out blood and the air.

These operations require general anesthesia and positive pressure in the lungs, a combination which is best produced by the Meltzer-

[1] Carrel and Tuffier: Loc. cit. [2] Carrel: Ann. Surg., July, 1914.

Auer method. In dealing with the heart itself local anesthesia may be added to control reflexes originating in that organ. Shock prevention and the maintenance of asepsis call for no new principles, but the protection of the exposed viscera from all unnecessary contact with the air and rough textiles by covering them with sterile silk napkins, vaseline soaked, is a method of great excellence. Suture material in the heart or vessel walls should always be of vaselined silk and the same is true of the pericardium, and the pleuræ too, if they have to be sutured after being accidentally opened. All needles should be round.

Laboratory experience, upon which all the foregoing technic is based, shows that none but healthy, vigorous young animals are suitable for the work, though one relatively old dog, eight years, was successfully operated upon. The lesson of this is that the plan could be considered only for the stronger and younger of human patients.[1]

All of the actual surgery of the human heart has been for the repair of wounds or of ruptures. The first repair of a heart wound was done in 1896 by Farina, and since then about 260 cases have been reported. The heart has been wounded by knife wounds or by bullet wounds, there being about five of the former to one of the latter, with a mortality in the stab-wound cases in which repair was attempted of about 49 per cent., and in the bullet-wound cases of bout 61 per cent.[2]

For bullet wounds of the heart the external wound of entrance may be anywhere on the thorax. Stab wounds must be within the length of an ordinary knife blade of the heart. LeConte and Stewart[3] found that the wound was between the sternal left border and the left mid-axillary line, and the second and seventh ribs in about eleven-twelfths of the cases, and of the other twelfth, two-thirds were in the upper abdomen, and one-third to the right of the sternum. There was but one case in which the sternum was penetrated. The nearer the external wound is to the heart the greater the likelihood of a heart wound too, but not a few stabs may enter the thorax and pass between the heart and the lung, with wounds of neither.

Inside the chest the pericardium is, of course, always wounded with the heart, and the left pleura participates in fully nine-tenths of the cases, the left lung in a slightly lesser amount.

The wound in the pericardium may be smaller than that in the heart, and the escape of blood from it may be slow so that the pericardial sac becomes distended. As the intrapericardial tension increases the pressure on the heart interferes with its function, and finally, as the pressure in the pericardium reaches the blood-pressure in the pulmonary veins and the auricles, blood is unable to enter the latter and the circulation of necessity ceases. This tamponade of the heart may occur with or without a wound of the pericardium. If the wound in the pericardium

[1] Tuffier and Carrel: Jour. Exper. Med., 1914, No. 1, xx. Carrel: Surg., Gynec., and Obst., August, 1914.

[2] Wagner: Deutsch. Ztschr. f. Chir., 1912, cxix, 221.

[3] Am. Pract. Surg., vii, 163.

is large the blood escapes from it as fast as it pours from the heart wound, and it then may appear in part or wholly on the surface, by the external wound, especially if there has been no collateral injury to the pleura. If there has been a wound of the pleura a pneumothorax is usually immediately produced and the mutual proximity of the pericardial and the pleural wound offers a path for the blood into the empty pleura and the pneumothorax becomes a pneumohemothorax. In these circumstances the lung is wounded one-half or two-thirds as often as the pleura.

Inside the pericardium wounds of the great vessels are practically not reported, but wounds of all the chambers of the heart are. Le Conte and Stewart found that the ventricles are wounded with equal frequency, that the ventricles are wounded about fifteen times as often as the auricles and that the right auricle is wounded nearly four times as often as the left. Combination wounds also occur, ventricle with ventricle and ventricle with auricle. Stewart[1] notes the difficulty in some instances of finding the wound in the heart, but usually this is easy for there is a systolic spurt of blood, and this though the wound may not open a heart cavity. Wounds may be pure stabs, or incisions, even as long as 7 cm.

While wounds from the outside are usually made by knives, a small percentage may be by needles, and needles swallowed may, in their travels, enter the pericardium and the heart. Knife wounds in the heart are possibly larger than the external wound, for the point of the knife may swing through an arc inside the chest, or the punctured heart may tear or cut itself on the knife in the act of beating. Occasionally knife blades are broken off and the point left sticking in the heart cavity or wall.

Bullet wounds are commonly, though not necessarily, double, and the missile may be encapsuled in the heart wall, or remain in a cavity, or may be rolled along the artery with the blood, or, again, the progress along the vessel may be against the blood stream and must be due to gravity, the opportunities for rolling along declivities in the vessels being offered by changes in the positions of the patients.

The diagnosis of surgical conditions has to count on the constant presence of variables in unusual quantity, but sufficient can be learned from an examination to warrant an exploration, and it is always better, Rehn says, to do an exploratory pericardiotomy, even if useless, than to overlook a wound of the heart.

The history of the receipt of a wound and its presence in or near the precordia may or may not mean a wound of the heart, but the nearer the external wound is to the sternum the greater is the likelihood of a heart wound, and bullet wounds which penetrate that bone are most liable to injure the heart too. Bleeding from such a wound may come from an artery of the chest wall, or from a wound of the lung, or of the great vessels or of the heart. The bleeding may be in spurts or in a con-

[1] Ann. Surg., July, 1913.

tinuous flow, and be much or little without definite diagnostic value as regards a wound of the heart. An acute general anemia must mean the loss of much blood, but this may be concealed in the thorax, as in a hemothorax, whatever be its source. A distended pericardium, after a trauma, penetrating or not penetrating, must mean a wound of the heart or the great vessels inside the pericardium, but it is not possible to say which is injured nor, in the case of the heart, which cavity is implicated. The history of a non-penetrating injury, as of a crush of the thorax, or the history of a wound and its presence, with or without external bleeding, but with an acute extreme anemia, with or without a hemothorax or a pneumohemothorax, with or without a distended pericardium would justify an exploration. The lung condition can be easily made out by an ordinary physical examination. Stewart[1] has shown that with a pneumothorax the cardiac dulness disappears and tympany replaces it. The heart sounds may, however, usually be heard but are faint, and adventitious sounds are rare, especially splashing sounds supposed to indicate air in the pericardium with the blood. Associated with these physical signs are the general ones: a weak and rapid, or no pulse and an incompetent circulation, mild or severe dyspnea, pain in the precordia and the left arm felt more acutely at expiration and made worse by pressure on the heart, violent left-sided pain in the abdomen and rigidity of the upper abdominal muscles. Finally, as tamponade of the heart supervenes, distention of the cervical veins and cyanosis, and stupor passing into coma.

If the external wound was an incised one and large enough, a finger might be passed in, or if the wound is small it might be enlarged sufficiently to admit a finger and indeed must be if exploration is done. The use of the probe is deprecated and Stewart[2] has pointed out that a stab wound through the chest wall has an angular course when the recipient lies down, due to the sliding upward of the skin and the moving upward of the heart in recumbency. Exploration of the wound should be carried far enough only to demonstrate that it entered the thorax and then, if there was evidence of serious hemorrhage the thorax should be opened to bring the parts inside into view.

If the wound is in the neighborhood of the heart it may be made the starting-point for an incision through the chest wall in the intercartilaginous space to the sternum, and then up or down along its left border and out in the second or third space so reached. This quadrilateral flap can be turned out by breaking the chondrocostal junction. In the case of a pneumothorax existing the lung has withdrawn out of danger, but if the pleura and lung are intact they should be pushed outward by gauze dissection and protected from injury. If the pericardium is distended it must be opened, whether there is a wound in it or not. If it is wounded the opening must be enlarged and the incision must be in the axis of the heart. All blood and clots in the pericardium should be rapidly swept out and the heart may be lifted and the fingers

[1] Ann. Surg., July, 1913. [2] Loc. cit.

of the left hand slipped into the pericardium behind it. Here the inferior vena cava can be felt and compressed between the first and second fingers, and by an upward pressure the superior cava can be closed.[1] With these vessels under control hemorrhage is controlled and a wound of the heart, if it is not at once obvious, can be thoroughly looked for. If one is found it must be sutured, and the material of choice is silk though catgut is permissible. The choice of the suture material is bound up in the question of sepsis. If the wounds are not infected, and one can expect the normal healing of the sutured heart and pericardium, the use of silk is beyond criticism. If, however, the pericardium has been opened widely and air has entered, or if the vulnerating instrument has been infected, suppuration inside the pericardium must be counted as a potential and then the silk suture is forbidden. Stewart[2] had infection persist in one of his cases until the silk suture which had been put into the pericardium was extruded. He afterward used catgut satisfactorily. Whatever material is selected, a close continuous suture is preferable as it is more quickly applied and has fewer knots; it should not penetrate the endocardium even in the case of penetrating wounds. With the hand behind the heart it may be lifted up to receive the suture and the first insertion may, after tying, be left long and used as a suspension for the heart and to steady it for the succeeding insertions. In experimental work on dogs it was found convenient to put into the heart two long suspension loops, dipped well into the myocardium, about 2.5 cm. apart. The experimental incision was then made between these opening a ventricle. The incision could be held open by drawing the loops apart, or it could be closed by crossing the loops and pulling the incision edges together. Hemorrhage could thus be controlled and sutures for the wound could be put in without haste.[3] It is not at all improbable that this method could be used in the case of large wounds bleeding freely, for two easily and rapidly placed sutures would control the loss of blood and the careful insertion of permanent sutures could follow. The needles used should be round, full curved medium size for the ventricles and smaller, of the same kind, for the auricles. No attention should be paid to the phase of the cardiac cycle when inserting or tying a suture. Great attention should be shown, on the other hand, to the coronary arteries and punctures of them or their inclusion within the bight of a suture should be avoided. The coronary veins, on the other hand, may be tied with practical impunity, the blood finding its way back into the heart through the foramina (Carrel and Tuffier). There is no practical difference in the way the ventricles behave when they are sutured, whether it be for stab wounds or for bullet wounds (Rehn). The auricles are more difficult to suture because of their sleazy structure and thin walls. Stewart has successfully sutured the right auricle even though Carrel and Tuffier name it as one of the dangerous regions of the heart[4] and others have done the same and had healing follow the suture.

[1] Rehn: Med. Press and Circ., 1908, xxii, 1.
[2] Loc. cit.
[3] Sherman: Jour. Am. Med. Assn., June 14, 1902.
[4] Loc. cit.

The closure of the pericardium after the suture of the heart wound is, like the suture material, bound up in the possible incidence of infection. Rehn's[1] statistics show little difference in results between the cases with drained and undrained pericardium, but this very fact is an argument for closure in the absence of obvious contra-indications. If it is closed without drainage a satisfactory number will have a normal healing. If suppuration occurs a secondary opening is possible. Drainage then may be by cigarette drain or by tube, and in some instances neither will be satisfactory. The drain should be near the heart apex and it should but just enter the pericardium to avoid the heart rubbing against it at each beat, though the same end may be attained by leaving the pericardium open at the apex and putting a drainage tube into the mediastinum to that point but not entering the pericardial sac. However the pericardium is closed and heals, there will probably be extensive adhesions between it and the heart, nearly or quite obliterating the sac.[2]

What should be done with the pneumothorax was formerly a major problem. Practically every one of the patients who lived long enough to develop an empyema did so, and so it was advised that the pleura should be drained at the first operation to anticipate infection and obviate a secondary thoracotomy. At the present day, with the positive pressure methods of giving anesthetics and preventing lung collapse when the thorax is opened, it is, of course, the method of choice for these cases, and at the end of the operation the lung should be completely distended and the pleura sutured and then the chest wall tightly closed. Even this will not surely prevent an empyema; the pleura is credited with less resistance to infection than has the peritoneum and its anatomy and physiology is such that its two surfaces, visceral and parietal, are always rubbing against each other in the respiratory act and opportunity for the walling in of a local infection is denied. Moreover, the pleura was not provided with an omentum. But the traumata of handling and suturing the parts must result in some adhesions, which may limit infection to a certain extent, and the vacant space of a pneumothorax is avoided by the method of closure, so that an infection would result in an ordinary or in an encysted empyema which could be relatively easily managed at a secondary minor intervention.

Rehn gives 40 per cent. as the incidence of infection, the form being septic pericarditis or empyema of the pleura chiefly, but he also saw abscesses of the lungs, pulmonary infarcts, phlebitis, purulent meningitis and cerebral abscess. There is naught more disheartening to a surgeon than to have an otherwise exemplary technic stultified by infection. The operator on emergency cases has the saving clause in the fact of this mischance, that he may divide the responsibility with the original wounding instrument. At the present time when skin disinfection can be practically properly accomplished in a moment by tincture of iodin, infection at the time of the operation should have

[1] Loc. cit. [2] Stewart: Loc. cit.

a smaller incidence and the infection that does occur should be referable more definitely to the time of the receipt of the wound.

Guibal,[1] calls attention to those cases of traumatic rupture of the heart in which the pericardium is intact. This may be caused by fractured ribs or sternum or a blunt missile, it may make a contused wound in the heart penetrating to the endocardium or not but not tearing the pericardium, or the rupture may be due to compression of the thoracic contents in which case the incompressible blood in the heart bursts the organ in its thinnest parts, that is, in the auricles, and the tear may extend into the large veins. If the heart continues to beat under these circumstances its tamponade is simply a matter of a short time. The recognition of this hemopericardium should not be difficult for the distended pericardium and the progressive weakening of the cardiac action and the increasing difficulty of hearing the heart sounds make a symptom-complex of great suggestive value which has only to be thought of to be appreciated. Two of these cases have been recognized and successfully operated upon.

THE PERICARDIUM.

The pericardium is a serous sac lying behind the sternum and the cartilages of the ribs and containing the heart, the beginnings and endings of the great vessels and a certain amount of serous fluid (Fig. 193). Anatomically it has a projection upon the surface of tri-

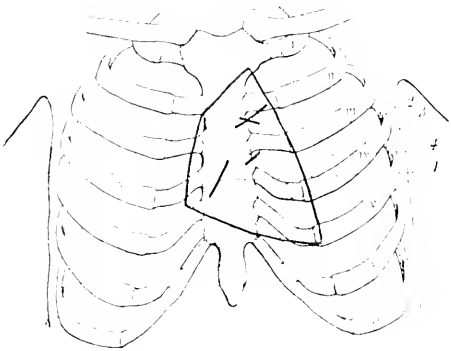


FIG. 193.—Projection of the pericardium on the anterior chest wall. (Modified from Terrier et Reymond.)

angular shape, the base of the triangle being below, the apex above. The base, or base line, begins in the middle of the fourth space, 2 cm. to the right of the right sternal border. It extends, with a slight curve downward, crossing the top of the xiphoid, to a point 6 cm. or 8 cm.

[1] Revue de Chir., 1905.

to the left of the left sternal border in the fifth space. On the right side the line of the triangle begins at the beginning of the base line and extends upward, with a slight convexity to the right, 1 cm. or 2 cm. from the right sternal border to the second cartilage, then it approaches and crosses the sternum toward the cartilage of the left first rib. The left side of the triangle begins at the left end of the base line and extends with a slight convexity to the left, to the same termination as the right side. Behind this triangle the pericardium lies. Anteriorly it is loosely bound to and is close to the back of the sternum, and posteriorly it is separated from the spine only by the contents of the posterior mediastinum; on the right and the left it has sides which are in contact with the right and left pleuræ and lungs respectively, and it is extensively attached below to the diaphragm. It has, then, the general form of an irregularly-shaped wedge, at the truncated upper point of which the aorta and the pulmonary artery pass out, while above and below toward the right the superior and inferior venæ cavæ enter, and behind the four pulmonary veins do the same. All of these vessels between the heart and the pericardium have a share of the serous coat which wholly or partly surrounds them. These vessels passing through the pericardial sac to the heart, divide the potential space inside the pericardium into chambers, or sinuses, which can be demonstrated by dilating the sac. There is one upon the right between the two venæ cavæ, one upon the left, in which the heart itself is to be found and above a space between the outgoing vessels and the pericardial wall. Both of the lateral spaces extend around toward the back.

Normally the pericardium contains about 15 c.c. of serous fluid, only enough to make a thin film between the epicardium and the pericardium. If by a trauma hemorrhage occurs into the sac, or by a pathological process there is effusion, these spaces are developed and distended, and then the heart, separated from its sac, takes certain locations in the fluid. Voïnitch-Sianojentzky demonstrated this on the cadaver, sitting or supine, and with an open or an intact pericardium. If a small amount of excess fluid, as 12 to 20 c.c. is introduced or accumulates in an opened pericardium, it will be found in the antero-inferior cul-de-sac, chiefly at the left side if the patient is upright, or on the right side and in the auriculoventricular furrow and about the origins of the great vessels of the base if the patient is supine. If, however, the opened pericardium is filled with fluid it envelopes the heart but is chiefly around the right auricle and ventricle, and also in the postero-lateral spaces if the patient is supine, and is between the heart and the diaphragm if the patient is erect.

In the intact pericardium there is some variation in the heart's place depending upon the amount of fluid which accumulates. With about 40 c.c. of liquid and the patient supine, the liquid collects above and below: above where the serosa is reflected upon the great vessels, and below in the antero-inferior limit of the sac (Fig. 194). With the same amount of fluid and the patient erect, the fluid collects about the apex of the heart (Fig. 195).

With increase in the amount of fluid conditions change, chiefly in degree, and when 400 c.c. have accumulated the fluid again accumulates above and below: above separating the whole heart from the anterior

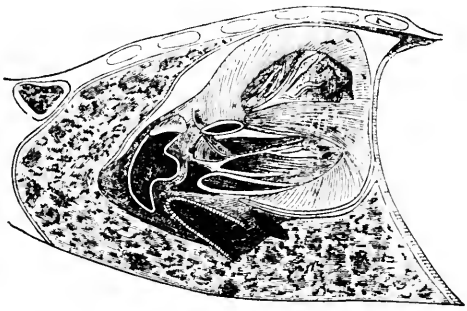


Fig. 194.—Intact pericardium containing 40 c.c. of fluid. Patient supine. (Terrier et Reymond.)

chest wall, and below separating it from the diaphragm if the patient is supine (Fig. 196) while if the patient is erect the fluid tends to accumulate below (Terrier et Reymond, Fig. 197).

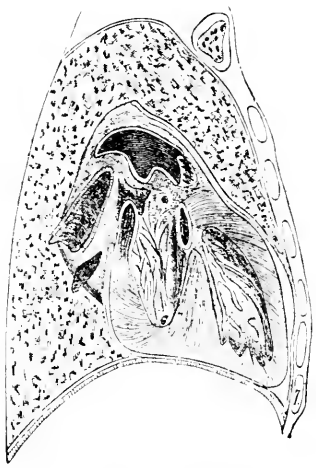


Fig. 195.—Intact pericardium containing 40 c.c. of fluid. Patient erect. (Terrier et Reymond.)

Matas points out in this matter that the fluid first fills the postero-lateral pouches on either side of the venæ cavæ and then collects above. When the amount increases the pericardium, because of the presence of the sternum in front and the spine behind, must distend transversely and downward and the heart is thus anchored above at its base by the vessels, but the ventricles and apex are floated and crowded forward and upward. The transverse distention may be very extensive and the

sac may reach out well to the right of the sternum, and to the left even as far as the mammary line or beyond it.[1] In all of these descriptions it is to be noted that the heart either does not recede much from the

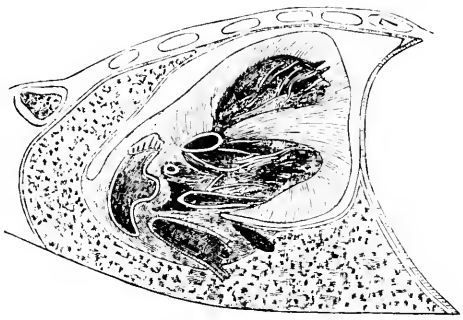


FIG. 196.—Intact pericardium containing 400 c.c. of fluid. Patient supine. (Terrier et Reymond.)

chest wall, or else is held firmly against it. It must also be remembered that the heart may be bound in some particular position by adhesions, in which case all rules of ordinary behavior are suspended, and the diagnosis of these adhesions is most difficult or quite impossible.

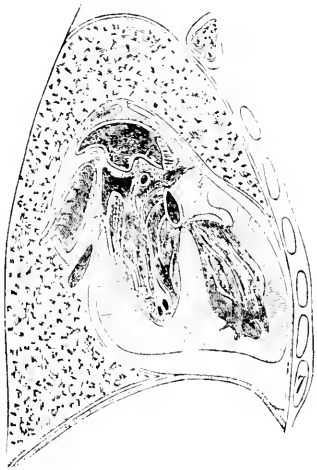


FIG. 197.—Intact pericardium containing 400 c.c. of fluid. Patient erect. (Terrier et Reymond.)

Normally the pericardium is in part separated from the ribs and sternum by the lungs and the two pleuræ. The two pleural sacs, separated from each other 1 to 2 cm., lie behind the left half of the sternum from the second to the fourth costal cartilages. At this point they

[1] Keen's Surgery, 1909.

both swing outward, the right to cross and run along on the seventh cartilage, the left more acutely so that it crosses the sixth and seventh cartilages near their middles. Inside the pleuræ the anterior borders of the lungs reach nearly to the same limits, except that the left lung at the fourth cartilage swings outward to the outer part of the fifth, and then inward to the middle of the sixth, forming the cardiac notch (Fig. 198). Over this space the pericardium has in front of it the structures of the chest wall. Below, as the pleuræ separate more widely they leave the pericardium quite uncovered over a small irregularly triangular space which includes the inner part of the sixth space. A needle or trocar introduced here, close to the sternum, will enter the pericardium without puncturing the pleura or wounding the internal mammary artery.

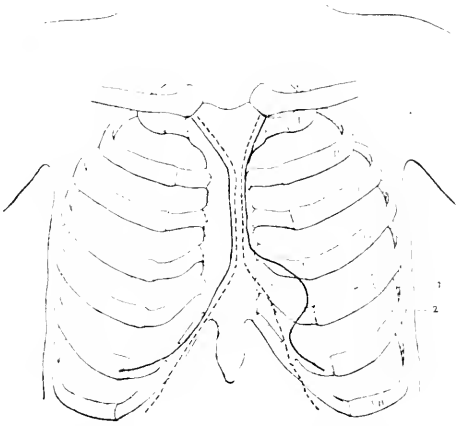


FIG. 198.—Common situation of the borders of the pleuræ and the lungs; broken line, pleuræ, continuous line, lungs. (Terrier et Reymond).

In those cases in which the effusion is considerable and the pericardium well distended, the lungs and the pleuræ are pressed outward so that the space not covered by them, in front of the pericardium, is increased and in addition the structures in front of the pericardium are compressed so that the distance from the skin to the pericardium is somewhat lessened.

The pericardium calls upon surgery for help when it is overdistended by an effusion or exudate so that the heart is obstructed in its work; when extensive adhesions have taken place between the epicardium and the pericardium, partially or wholly obliterating the potential space and then the process has continued extrapericardially, a mediastinitis, and has locked the anterior layer to the back of the sternum over a greater or less extent and again interfered with the work of the heart. Injuries to the heart which require surgical treatment necessitate the opening of the pericardium to expose that organ, but then the pericardiotomy is but an incident in the technic.

Exudates occur in the pericardium as they do in other serous sacs. Effusions occur in the pericardium in connection with inflammation

due to general infections or as an extension of the infections of neighboring organs, or as an extension of an endocarditis. The relief of the pressure upon the heart and obstruction of its work can be accomplished by aspiration or incision and drainage.

Aspiration may be considered indicated if the contents of the distended pericardium are believed to be a sterile exudate or a hemorrhage. Aspiration of a septic fluid exposes the needle track through the mediastinum to infection and thus to inaugurating a mediastinitis or even a pleuritis in those cases in which the pleura has intentionally or accidentally been traversed. Aspiration should be done by using a Dieulafoy aspirator, and the vacuum in the syringe should be connected with the needle as soon as the latter has well entered the tissues. The point of selection of Voïnitch-Sianojentzky, which consists in puncturing directly from before backward in the inner part of the sixth space, is the simplest and gives the best results. The needle should be pushed no farther than 2.5 cm. into the tissues and if no fluid has been secured by the time that depth has been reached, it is best to carefully withdraw the needle. If fluid is gotten and is sterile, the pericardium should be partially emptied. Entering the pericardium at this level the needle point should be below the apex of the heart and in the midst of the lower accumulation of fluid in the antero-inferior part of the pericardium. As the pericardium is emptied and the walls relax, the heart descends and approaches the needle, and if it touches it the needle receives the rhythmic impulses of the heart beat. The danger of puncturing and of tearing the heart muscle—a danger which was avoided in the beginning by the selection of the inner part of the sixth space for the puncture—is now encountered and an endeavor must be made to turn the point away from the heart until all the fluid that it is safe to remove has been evacuated.

The accidents which may mar this procedure are puncture of the internal mammary vessels, puncture of the pleura, puncture of the heart. The first is avoided by selecting a puncture point internal or external, preferably of course internal, to the vessels. The point above indicated will always escape the vessels. Puncture of a sound pleura is of no moment if the fluid in the pericardium is not septic. Terrier et Reymond quote Kussmaul as having punctured 1.5 cm. to the left of the sternum, getting immediately a yellow liquid, and a little deeper considerable pus. The experience was repeated four days later. Evidently the clear fluid came from the pleura and the pus from the pericardium. In doubtful cases, it is plain to see, an inaccurate puncture might not disclose whether the pus came from the pleura or the pericardium. An accurate puncture which should avoid the pleura, or a secondary puncture at a place where the pleura alone could be reached would clear the matter. Puncture of the heart has been fatal instantly or immediately or after a short time, but this has happened only in hearts with a diseased myocardium. Puncture of a sound heart muscle, even though there be considerable hemorrhage, does not interfere with heart action unless it be in the danger regions around the right auricle,

and, other things being equal, the punctured wound heals readily. If the coronary artery of the heart be wounded or torn the hemorrhage may be serious, but the real danger will be the degenerative changes in the myocardium supplied by the artery. Wounds of the coronary vein are of much less moment.

In cases in which the pericardial effusion can be affirmed, on a sufficiently well worked out diagnosis, to be septic, aspiration is not competent to control the condition and incision and drainage are needed. The same is manifest if aspiration is done and the fluid secured is found to be septic. Operations of this type are most likely to be emergency matters which do not permit elaborate technic, and, in addition, they may need to be done by the operating general practitioner. Therefore the simplest possible procedure should be followed. The debatable point is that at which the chest wall should be opened to permit the uncovering of the pericardium. The method which combines direct and simple approach to the pericardium, and also gives opportunity for extensive uncovering of the heart should that prove to be necessary, is that of Kocher. He "makes an incision down to the bone from the middle line of the sternum outward toward the left side at the level of and following the line of the sixth costal cartilage. If required the incision may extend to the left mammary line. Separate the perichondrium and all the soft parts from the sixth costal cartilage and excise the cartilage. This exposes the triangular muscle of the sternum with the mammary vessels which are ligated if necessary. Divide the tendinous insertion of the triangular muscle into the sternum. The dense, glistening pericardium now lies exposed, and if drainage alone is required it may be opened and the operation is complete. If more room is required, from the sternal end of the horizontal incision cut upward in the mid-sternal line to the desired extent (usually to the level of the second rib). Separate the periosteum and soft structures from the sternum to the left of the median line. Divide the fifth, fourth and third left costal cartilages at their insertions into the sternum. Through the horizontal wound push the exposed margin of pleura outward. Gradually lift up the fifth and even the fourth and third costal cartilages slowly and gently pushing back the pleura from their deep surface. After separating the flap from the pleura, fracture or divide the costal cartilages in the flap, at their junction with the corresponding ribs. When this is done the flap can be completely reflected. Split the pericardium along the sternal margin and laterally along the fifth interspace. This gives access to the heart from the auricles to the apex of the ventricles. If more room is desired excise a sufficient portion of the sternum by means of rongeur or bone forceps."[1]

Drainage of the pericardium should be by a cigarette drain of sufficient size or by a tube. The drain should go *to* the opening in the pericardium but *not* enter it, and should be fixed in this location. If

[1] Binnie: Operative Surgery.

the drain enters the pericardium the heart traumatizes itself by friction against it. Draining from the antero-inferior cul-de-sac of the pericardium has no gravity effect on the upper accumulations of fluid while the patient is supine; it is effective, however, if the patient is semi-erect or erect, or is prone or in the left decubitus.

The course of the case controls the length of the time of drainage.

Acute pericarditis may eventually become chronic and result in leaving the pericardium more or less thickened with adhesions between the two layers of the sac. An important type is that in which the connective tissue of the mediastinum is implicated and thickened so that the heart may be firmly united to the chest wall, the lungs and the diaphragm—*indurative mediastinopericarditis* (Adami and Nicholls). If the process is limited to the pericardial sac it is most difficult of

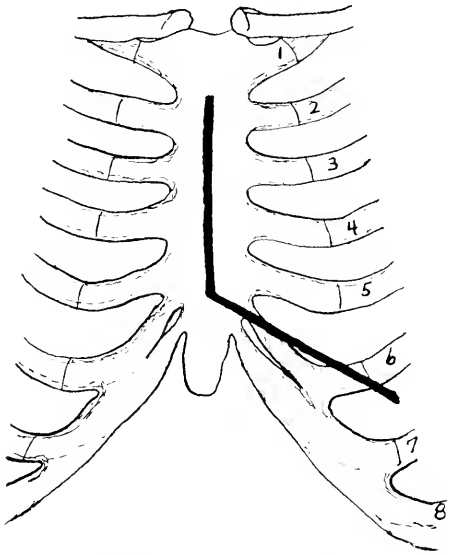


FIG. 199.—The lines of incision of Kocher's pericardiotomy.

diagnosis for the adhesions may be local[1] or general, when it constitutes symphysis of the heart. The complex naturally includes cardiac hypertrophy and it is not possible to differentiate between a simple hypertrophy and one with a symphysis added. For this condition, if it could be recognized, Delorme suggested the operation of cardiolysis, in which the pericardium should be opened and the heart be freed from its adhesions, but the proposed operation has found no favor, not because of any particular difficulty in doing it, but because of the certainty that the adhesions would reform in the ordinary process of healing and that therefore nothing would be gained. Moreover, these intrapericardial adhesions are of not much injury to the heart during life and so the need for freeing the heart from them is not so

[1] Delorme: Gaz. d. hôp., Paris, 1914, lxxxvii, 963.

great.[1] It is different if the adhesions are also extrapericardial, Adami's indurative mediastinopericarditis. In this case the heart makes a direct pull upon the rigid sternum and ribs at each systole, and as they can yield but little if any the base must be moved rather than the apex, that is, the relatively fixed part of the heart is the apex and not the base.

Delagenière[2] gives an excellent symptomatology and includes both many signs of common presence in cardiac complexes, and some which are less ordinary and more indicative of the adhesions. The ordinary symptoms are dyspnea, precordial pain and tenderness. The exceptional are a bulging of the precordium with a retraction during the systole and a systolic deepening of the epigastric hollow, the former being due to the heart's systolic pull upon the sternum and the latter's recoil during diastole, while the epigastric depression is due to the pull upon the diaphragm. As evidence of the cardiac hypertrophy is the increase in precordial dulness and murmurs at the various orifices, due to the valvular incompetency of the dilated though hypertrophied heart, and a tendency to embryocardia, a reduplication of the heart sounds.

In general there is edema, ascites, hypertrophy of the liver and albuminuria.

Radioscopy is of great value in the diagnosis for it shows the heart shadow enlarged, and that the apex and sides are immobile.[3]

For this condition an operation has been suggested by a medical man, Brauer, of Marbourg, which he called cardiolysis, but which Delagenière calls pericardiolysis, leaving the word cardiolysis to apply to the operation inside the pericardium suggested by Delorme. Kocher called it *thoracolyse precardiaque* and Thorburn *precardial thoracostomy*.[4] The operation, suggested in 1902, had been done fifteen times according to Thorburn in 1910, and to these Thorburn added one case; of these all but two were markedly benefited and some were restored to the ability to do heavy work. The operation is simple and wholly extrathoracic. A curved incision is made along the left border of the sternum uncovering the third, fourth and fifth cartilages, and the soft tissues are turned back to the ribs or beyond if needed. These cartilages are resected and some of the ribs, in all 8 cm. or 10 cm. of each. It is advised to remove the superficial perichondrium and periosteum, but not the deep. If the heart now impinges against the edge of the sternum that bone is cut away with rongeurs enough to free the heart. The musculocutaneous flap is replaced. The heart is thus freed from its attachment to the rigid chest wall; the flexible layer of tissues to which it remains fixed readily follows its movements and the obstacle to its competent function is removed. The operation has most commonly been done under a general anesthetic, but local anesthesia is practicable.

Primary tumors of the pericardium are most difficult of appreciation

[1] Lecene: Arch. de mal. de cœur, etc., Paris, 1909, ii, 673.
[2] Bull. de l'Acad. de Méd., 1913, 539, et seq.
[3] Vaquez et Bordet. Quoted by Delagenière.
[4] Brit. Med. Jour., 1910, i, 10.

during life, and are generally necropsy discoveries. They are frequently malignant and may occur at any age from fifteen to seventy-five.[1]

Postscript.—The surgical treatment of wounds of the pericardium and heart in war surgery reports has followed the lines already laid down by civil practice. This is really as it should be, and General Cuthbert Wallace, of the Royal Army Medical Corps, is quoted as saying: "The more war surgery approximates to civil surgery the better it will be."

Numerous operations have been done and have demonstrated the simplicity of uncovering the organs. The incisions for exposure traverse practically only connective tissues, an intact pleura can be pushed out of the way, the internal mammary artery is the only vessel likely to be encountered, the cartilages of the ribs are not difficult to deal with and the chest wall after closure is equally competent if these be retained and restored to place or not. Lavage of the pericardial sac has been done, drainage of it has sometimes been practised, usually it has been closed, and this last is the proper practice unless there has been an obvious infection. Once the pericardium was packed to control an otherwise uncontrollable hemorrhage with, of course, a fatal issue.

Infection of the opened pleura has not been uncommon, but has usually been easily managed.

This operative work can be and has been done under local anesthesia, and the fact of the insensibility of the pericardium and heart to pain by being handled was noted.[2] That manipulation was painless, but that lavage of the pericardium by ensol, by hypertonic salt solution and by physiological salt solution was very painful, while a weak solution of iodin was painless, was pointed out by Jones.[3]

The importance of operating in those cases in which the diagnosis was not convincing, but in which there was a reasonable belief of the need existing, was as great as in analogous abdominal matters. Rehn insists on the obligation of the surgeon under these circumstances. That the surgeon must think of and be able to recognize heart tamponade is evident, and that heart tamponade may exist without an external wound must not be forgotten. Jones[4] reports a successful intervention for tamponade following a stab wound and Rhodes[5] reports two, one succeeding and one failing.

The importance of looking for small wounds in the heart is insisted on. One case in which a small wound was not found at the operation, the patient bleeding to death, is recorded,[6] and another in which such a wound was found and successfully closed.[7]

[1] Forni. Tumore, March, April, vol. iv, No. 5.
[2] Gray, Birbeck and Lorimer: British Med. Jour., October 16, 1915, p. 561.
[3] British Jour. Surg., No. 13, vol. iv, p. 103.
[4] Ann. Surg., 1917, lxv, 119.
[5] Ibid., lxvi, 44.
[6] Müller: München. med. Wchnschr., July 28, 1914, No. 30, p 1679.
[7] Dixon and McEwen: British Med. Jour., 1916, i, 755.

A number of cases of the removal of pieces of shrapnel or of bullets from the heart muscle at primary or secondary interventions are given. The fact of the presence of the missiles was shown by radiograms, or the missile could be seen to move with the heart by the fluoroscope. Various symptom-complexes were recounted; easy fatigue, inability to stand erect, dyspnea, absence or presence of pain, cardiac disability, are some of the symptoms suggestive of a heart wound with a retained bullet. Most of these missiles were located in the ventricles. In one instance a bullet near the ventricular apex was associated with injury to the bundle of His, with complete heart-block, due to the latter lesion. Wounds of the right auricle have been reported without the necessary fatalities experimental work would seem to call for. One right auricular wall carried a bullet six months, when it was removed because it disturbed heart function. This patient died,[1] but Fraser[2] and Nassau[3] both report successful sutures of the right auricle.

Nothing is said, of course, about the danger regions in the heart. If a wound by a bullet was made in a *noli me tangere* place in the heart, that heart never came for surgical help, and a heart that came for help would be entitled to help no matter where the wound was, but (and this advice is not based on any experience gained in war surgery particularly) the surgeon closing a wound in a heart should be careful not to wound a coronary artery by his needle or to include them or any of their major branches in his sutures.

In the case of the heart, when traversed by a high-velocity bullet, death is usually instantaneous, the dynamic disturbance causing it to stand still. Failing an instant paralysis, the wounded heart bleeds so freely and rapidly that death occurs in a few minutes. In big-game shooting it occasionally happens that a large beast is brought to the ground by a broken back. When such an animal is deliberately finished by a bullet sent through its chest, either fore and aft, or from side to side, it dies instantly. On opening the chest, the heart will be found firmly contracted, and often there is no effusion of blood, either in the cavity of the pericardium or of the pleura. The effects of a sword plunged into the heart may be watched in the bull-ring. When the matador thrusts the weapon directly into the heart, the bull sinks instantly on the floor of the ring; but when the sword wounds the big vessels at the base of the heart, the bull may move about for many seconds while the blood escapes.

In previous wars little attention was given to gunshot wounds of the heart; they have been regarded as nearly always fatal. Indian sportsmen have often drawn attention to the fact that a tiger, shot in the heart, has had the strength to run for many yards before falling dead. Some of the hearts in the collection show the destructive effects

[1] Rev. de Chir., Paris, December, 1915.
[2] Edin. Med. Jour., January, 1917.
[3] Ann. Surg., 1917, lxv, 119.

which modern missiles exert upon the thick walls of the ventricles. One heart extensively lacerated near the apex by an armor-piercing bullet, merits attention. It belonged to an officer who was hit when flying over the German lines. He brought the aëroplane to earth in his own lines, but was dead when removed from the machine.

Farina, in 1896, proved that wounds of the heart are amenable to surgery; and his example influenced the treatment of such wounds during the Great War; there are specimens illustrating surgical enterprise in this direction. But the surprise of the collection is a series of specimens indicating the methods and routes by which missiles reach the cavities of the heart; they prove that missiles occasionally enter the cardiac cavities by directly penetrating the walls of the heart, or arrive as flotsam and jetsam in the blood stream. The evidence supplied by the specimens shows that fragments of metal, and entire bullets—shrapnel and rifle—penetrate large veins, such as the pulmonary, iliac, hepatic and caval, and are transported as emboli to the heart. Some of the missiles, after reaching the auricular or ventricular cavities have been retained. A few, embedded in clot, have been discovered post mortem. In several instances, bullets have been detected radioscopically in the heart cavities during life, and their swirlings and gyrations in the blood current during systole and diastole, have been watched with the same interest that astronomical observers bestow on minor planets.

In some instances, bullets round and conoidal, or irregular fragments of metal, after reaching the cavity of a ventricle, are discharged and become dangerous emboli. There are specimens in the collection, exquisitely prepared and displayed, showing metallic emboli impacted in the pulmonary artery producing infarction of the lung. Others, lodged in the iliac arteries, caused ischemia of the lower limb.

Even more remarkable are the specimens proving that bullets may penetrate large bloodvessels, like the aorta, and become centrifugal emboli, being propelled by the arterial current, or slip along the vessels by their own weight, until they become impacted in the common or the external iliac artery. These extraordinary events and sequences are not only represented by specimens, but complete clinical histories are available; the names of the officers who made the observations and carried out the treatment are duly recorded.

In a few cases the missiles within the chambers of the heart came as a postmortem surprise, but in many instances the nature of the embolus has been recognized during life; in one instance a missile was observed in the heart radioscopically, and a few hours later it was detected by the same method in the common iliac artery (O'Neill). The parts belonging to this remarkable case are preserved in the Museum.—*British Journal of Surgery*, July, 1919, "Introductory," by J. Bland-Sutton.

SURGERY OF THE LIVER AND GALL-BLADDER.

By JOSEPH RANSOHOFF, M.D., F.A.C.S., F.R.C.S., (Eng.)
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THE LIVER.

ANATOMY OF THE LIVER.

The liver which develops from the foregut is part of the digestive system, both from an embryological and a functional viewpoint. It is the largest gland in the body, and its average weight in the adult male is about 1520 grams. The liver is situated in the upper portion of the abdominal cavity, occupying almost the entire right hypochondrium. It extends through the epigastrium and into the left hypochondrium to a variable degree. It is behind the right seventh, eighth, ninth, tenth and eleventh ribs and their cartilages, the ensiform cartilage, and the sixth, seventh, eighth and ninth left costal cartilages. In this way it is fairly well protected from all external injuries except those of great force.

The liver is movable to a limited extent, following the diaphragm in its respiratory excursions. During inspiration the upper surface of the right lobe reaches the upper border of the eighth dorsal vertebra. Unless the liver is enlarged its lower right border lies under the thoracic margin and cannot be felt except in very thin subjects during deep inspiration. The lower border of the left lobe can usually be felt in the epigastrium, directly below the costal angle.

The position of the liver varies with posture in the erect adult; its lower border follows a line drawn from the eighth left to the ninth right costal cartilage. In children the liver occupies a much larger relative space, filling a large part of the abdomen, often reaching the umbilicus. This is of surgical importance in planning abdominal incisions in young children.

The relations of the pleura to the liver are important from a surgical viewpoint. On the right side the pleura is reflected from the chest wall to the diaphragm, along a line extending from the back of the ensiform cartilage, downward and outward along the seventh costal cartilage. In the nipple line this reflection is at the level of the eighth costal articulation. In the midaxillary line it is beneath the tenth intercostal space, while near the spine it is at the level of the eleventh

rib or slightly below. The lowest point of the pleural reflection is in the midaxillary line. This reflection is, as a rule, but two inches from the lower border of the liver. When the liver is enlarged upward the diaphragmatic and the parietal pleura are brought into close contact. This is of assistance in certain forms of abscess of the liver pointing on the superior surface, where the parietal and diaphragmatic pleura become adherent, obliterating the costophrenic space. This permits the opening of these abscesses without invasion of the pleural cavity.

The liver is connected to the diaphragm by the coronary and suspensory ligaments. Except between these ligaments the liver is entirely covered by peritoneum. The anterior reflection of the coronary or lateral ligament forms the falciform ligament, which attaches the liver to the diaphragm and the anterior thoracic wall. This ligament extends to the umbilicus and encloses in its anterior border the ligamentum teres, which represents the remains of the obliterated umbilical vein; except at the umbilicus it is situated to the right of the middle line.

The anterior border of the liver is sharp and thin and contains about in its center, opposite the ninth costal cartilage, the notch for the gall-bladder. To the left of this is the notch where the round ligament enters. Its under surface is irregular, to conform to the organs with which it is in close relation, or perhaps, more correctly stated, on which it rests. The right and left lobes are separated by the longitudinal fissure. Besides the right and left lobes there are three others, which are really subdivisions of the right lobe: the lobus Spigelii, the lobus caudatus and the lobus quadratus. Anatomical variations of these small lobes are not infrequent and are usually of only academic interest. Accessory lobules are not uncommon. One of these is occasionally found attached to the neck of the gall-bladder.

In some individuals a long, tongue-shaped prolongation of the right lobe is found, called Riedel's lobe. It may be attached either to the right or to the left side of the gall-bladder, which it may completely conceal. In some instances it is connected to the liver by an attenuated pedicle, so that it may form a distinctly movable abdominal tumor. It may be mistaken for enlarged gall-bladder, tumor of the liver or even for a tumor of the right kidney. This Riedel's lobe has been regarded by some as the result of tight lacing. This theory, however, is untenable, as it is not infrequently found in men, and may even grow from the left lobe. From observations it has been supposed to be invariably associated with gall-stones. This, however, is not true.

The liver rests directly on the stomach, transverse colon and right kidney, and there are niches on its lower surface into which these organs fit. The chief support of the liver is its intimate connection with the inferior vena cava, through the openings of the large hepatic veins. Passing upward to the heart the vena cava is intimately adherent to the posterior abdominal wall and passes deeply through the liver tissue, where it receives the large tributaries of the hepatic vein. In this way the liver is firmly fastened to the posterior abdominal

wall and the diaphragm. The coronary ligaments also assist in supporting the liver. The general intra-abdominal pressure and the correct position of the organs on which the liver rests also play a distinct role. The liver is only displaced in extreme degrees of enteroptosis.

The liver is surrounded by a dense fibrous capsule called Glisson's capsule. Prolongations of the capsule enter the liver at the transverse fissure with the hepatic and portal vessels. These capsular prolongations follow the vessels into their smallest ramifications and form the capsules of the individual lobules.

The liver is supplied by the hepatic artery, which enters the liver through the gastrohepatic omentum, with the portal vein and the common duct.

The liver is rarely in anomalous position except in complete transposition of the viscera. Occasionally gall-stones have occurred in these cases and have required operation. Such cases have been reported by Beck, Billings and Mayo. Robson described a case in which the liver assumed an almost vertical position.

DISPLACEMENTS OF THE LIVER.

Prolapse of the liver is a not infrequent condition, and occurs mostly in conjunction with general abdominal ptosis. It is, as a rule, rather a medical than a surgical condition. The frequency may be estimated by a report of Einhorn, who in the course of a year's work found 21 cases of hepatoptosis in 369 females and 9 cases among 439 males. It must be remembered, however, that his clinical material is largely gastro-intestinal.

The causes are those common to abdominal ptosis. It usually occurs in women whose abdominal walls have become relaxed through emaciation or repeated childbirth. There is a well-recognized enteroptotic habit which has a peculiar conformation of the body. The thorax is long and thin and the neck also is long and thin. The costal arch is acute and the costo-iliac interval very long. These are the patients who very frequently are supposed to be threatened with tuberculosis, and are rarely in perfect health.

Albu[1] showed that hepatoptosis is a very frequent accompaniment of general enteroptosis. He found among 3400 patients examined that it was twice as frequent as left nephroptosis and half as frequent as right nephroptosis.

Hepatoptosis may be divided into five classes, according to symptoms (Einhorn[2]): In the first class of cases the hepatoptosis is found and causes no symptoms. The second class is dyspeptic, the third class has pain in the liver and a dragging pain up the right abdomen and shoulder. The fourth class may have attacks resembling gall-stone colic. The fifth class has attacks resembling asthma.

[1] Berl. klin. Wchnschr., 1909, vol. vii.
[2] Jour. Am. Med. Assn., 1916, lxvi, 1908.

Symptoms.—As a rule the symptoms of hepatoptosis are overshadowed by the general symptoms of enteroptosis. These patients are classed as dyspeptics, or, more frequently, as neurasthenics, and are not infrequently very difficult to relieve. The diagnosis is easily made by the palpation of the displaced liver, which, of course, may be confirmed by *x*-rays.

Gouba[1] has described a very interesting case of hepatoptosis occurring in a child, aged nine years. There is reason to believe that a low stand of the liver with elongation of the suspensory ligament may be congenital. Abnormal elongation of the vena cava may also, according to Faure,[2] be a factor in the descent of the liver. There is no question that the relaxed abdominal wall is one of the most important causes for this condition.

Treatment.—The treatment is, as a rule, purely orthopedic, dietetic or medical, and should be directed toward an improvement in the patient's general condition. Rest and fat cures are particularly advisable, in addition to that a well-fitting abdominal band should be worn, to keep the viscera in proper place.

During recent years the surgical treatment of enteroptosis has come into great prominence, but seems rather to be losing than gaining favor. Billroth was the first, in 1884, to practice the surgical correction of hepatoptosis. Werelius collected 66 operations of this kind in 1912. Of these cases only 2 were in males, and there seems no question that repeated pregnancy had a great deal to do with the condition, as only 4 of the patients were nulliparæ. The enlarged Riedel's lobe, which may attain great size and extend far down into the pelvis, cannot be considered a true hepatoptosis.

The following different methods of suspension have been used: Billroth placed deep sutures through the liver tissue and capsule, which he carried through to the abdominal wall and tied over iodoform gauze. Treves sutures the liver to the xiphoid process, Ramsey to the seventh ribs. Le Ford, Poppert and others have fastened the liver by means of the gall-bladder. Depage aimed at the correction of the displacement by a plastic operation of the pendulous abdomen.

Various methods have been used to promote adhesions between the upper surface of the liver and the lower surface of the diaphragm by scarification, by the knife, or by cauterization with the thermocautery or even by packing.

Gross in a case of extreme prolapse of the liver used the ligamentum teres with good result. After separating the ligament close to the umbilicus he raises the liver by sharp upward traction, the free end of the band was then passed through the ninth intercostal space, where it was held in place by a chromic catgut or kangaroo tendon suture. He was able to raise the position of the free border of the liver at least 10 cm. by this maneuver. After all is said and done there are prob-

[1] Deutsch. med. Wchnschr., 1915, xli, 450.
[2] l'Hepatoptose et l'hepatopexie, Thèse de Paris, 1892.

ably but few cases of hepatoptosis which need be considered from a surgical point of view, as the vast majority of the cases are only part of the general condition of enteroptosis.

INJURIES OF THE LIVER.

Injuries of the liver are not uncommon in civil practices. There are three varieties of injuries of the liver: (1) crush wounds; (2) shot wounds; (3) stab wounds. In civil practice the most important and by far the most frequent of these injuries are the crush wounds. This may be explained in several ways. When the abdomen is struck by a powerful force, any one of the organs of the peritoneal cavity may be injured. However, of the solid organs of the abdomen the liver is the one most frequently injured in this way, either alone or combined with other abdominal injuries. Of 305 subcutaneous injuries of the solid abdominal viscera collected by Tilton[1] there were 189 cases of liver injuries.

The reason for the frequent injury of the liver is its fixed position to the diaphragm and chest wall. Because of this the liver is unable by slipping and changing its position to evade the injuring force. Those liver injuries which are combined with injuries of other organs, particularly the hollow viscera, are not of great surgical importance, as the combined injuries usually lead to a rapid fatal termination.

In his article on liver injuries, Kehr[2] divides these subcutaneous liver injuries into three groups: (1) True ruptures of the liver with a tear of the capsule; (2) the separation of the capsule from the liver substance by subscapular bleeding; (3) central subscapular ruptures of the liver, which may lead later to cyst formation and to multiple liver abscesses. This division, however, cannot be followed out clinically, as it is impossible to differentiate between classes (2) and (3).

Finsterer[3] divides these injuries of the liver into two classes: (1) The penetrating liver rupture, in which the capsule is torn and the rupture opens freely into the peritoneal cavity; (2) the subscapular rupture, which include classes (2) and (3) of Kehr's classification. It is easily seen that the symptoms of these two groups will be entirely different, as in group 1 the symptoms will depend largely on the free hemorrhage into the peritoneal cavity, which is impossible in group 2.

It seems wise to take up the diagnosis and prognosis of this class of cases apart from the stab and shot wounds of the liver, as the symptomatology and diagnosis is almost entirely different. The comparative frequency of these subcutaneous ruptures of the liver in civil practice is brought out by a few statistics compiled from certain German clinics. Of the cases reported from three large German clinics there were 25 ruptures, 11 shot wounds and 4 stab wounds. However, in other countries in which the carrying of knives or revolvers is more

[1] Ann. Surg., xli, 20.
[2] München. med. Wchnschr., 1903.
[3] Deutsch. Ztschr. f. Chir., v, 10.

prevalent, stab and shot wounds assume a relatively more important role. This is particularly true in Russia, where stab wounds of the liver are very frequent.

Symptoms.—The symptomatology of these subcutaneous ruptures of the liver depend largely on the severity of the hemorrhage. As they are usually caused by very severe trauma, as, for instance, the crushing of the body between two cars or fall from a height, these injuries are nearly always accompanied by severe shock, which for the time being masks the special or localizing symptom. However, in certain cases shock may be entirely wanting. Cases have been reported in which, with a most severe injury of the liver, the patient walked into the clinic to die a few hours later. Von Hippel reports the case of a twenty-eight year-old officer whose liver was ruptured by a fall from his horse. The officer was able to walk to the clinic. Operation disclosed a complete tearing off of the left liver lobe.

The most important symptoms of liver rupture depend on the extravasation of free blood into the peritoneal cavity. These symptoms are common, of course, to injuries of all abdominal organs. The abdomen becomes rigid and tender. However, in injuries of the liver in common with injuries of the upper abdomen the rigidity is principally localized in the upper recti muscles above the umbilicus. As liver injuries are the most common of the subcutaneous injuries of this region a great rigidity of the upper recti after a crushing injury is very suggestive of liver injury. If the hemorrhage is a severe one the symptoms of severe intra-abdominal hemorrhage are significant; that is, weak pulse, pallor and progressing weakness.

Finsterer has pointed to a very important sign on the part of the pulse in injuries of the liver: that is, the comparative or even absolute bradycardia. All other forms of intra-abdominal bleeding are accompanied by rapidly increasing pulse-rate. In Finsterer's experience, in nearly all of his cases, particularly when they were watched carefully, the first shock was followed by a definite and often absolute slowing of the pulse. If a pulse of 80 to 90 accompanies a profuse intra-abdominal hemorrhage this must be considered a true bradycardia, as in the usual case the pulse here might range between 120 and 150. Of 13 cases collected by Finsterer from the literature there was a slowing of the pulse in each one, varying from 64 to 80 to 90. All these cases were shown either by operation or postmortem to have sustained a very severe injury of the liver. This bradycardia is an important diagnostic symptom, particularly when accompanied by symptoms of intra-abdominal hemorrhage. This bradycardia must be considered rather a negative than a positive diagnostic symptom: that is, a bradycardia accompanying symptoms of intra-abdominal injury should not militate against the probability of intra-abdominal hemorrhage, but should rather point to the possibility of hemorrhage from the liver.

Pain, if present in the liver region, particularly if reflected to the back and shoulder, is extremely suggestive of a liver injury. The character of the injury must be taken into consideration, and it must

also be borne in mind that the liver is the most frequently injured of all the intra-abdominal solid organs. Frequently the severe shock which accompanies all these injuries make an exact diagnosis impossible.

Jaundice when present is a significant symptom, as it points almost conclusively to a liver injury. As it does not commonly occur until several days after the injury it is not of essential diagnostic importance. The diagnosis must then be made by the direction of the offending force, the shock, the pain in the liver region and the symptoms of intra-abdominal hemorrhage. The prognosis depends entirely on the severity of the hemorrhage. In many instances slight liver injuries undoubtedly recover without sufficient symptoms on which to base a diagnosis. On the other hand, injuries with profuse intra-abdominal hemorrhage are fatal unless surgical interference is carried out.

In civil practice an exploration should be made in every case in which the symptoms point to severe intra-abdominal injury. Even in the presence of shock, when symptoms of grave intra-abdominal hemorrhages are present, operation should not be delayed. If necessary blood transfusion should precede or follow the operation.

Shot wounds of the liver are common in modern warfare, and their severity depends entirely on the nature of the projectile. The small caliber modern bullet may completely penetrate the liver with minimum destruction of tissue and but slight hemorrhage. In these cases the diagnosis can only be made by noting the course of the bullet. However, the characteristic pain may be present.

These liver injuries are frequently complicated by a coexisting injury of the lung, which may completely mask the symptoms of liver injury. In some instances, however, death has ensued from a comparatively slight liver injury: that is, when the bullet has made a superficial furrow in the liver surface, with an accompanying fatal hemorrhage.

Shell wounds of the liver are far more serious. There is often seen an explosive action on the liver with tremendous destruction of liver tissue leading to a rapidly fatal termination. In other instances, after tearing a great jagged hole, the projectile may come to rest in the liver tissue after carrying with it some foreign material.

The symptoms of liver injuries in war are much like the symptoms of liver crushes, except that the course of the projectile simplifies the diagnosis. In case the wound of entrance and exit are large the escape of bile from the wound is not an uncommon symptom. Jaundice is frequent in shot wounds of the liver. Of 37 cases observed by Makins[1] in a base hospital, 12 had marked jaundice. It is probable that when severe hemorrhage occurs most of those cases die before aid can be brought. However, secondary hemorrhage occurring from ten days to four weeks after the injury is not an unusual occurrence. This, of course, is most frequently due to an accompanying sepsis. In a number of cases which came to postmortem ten days to six weeks after the injury a wide spread of infection was observed. The track of the pro-

[1] British Jour. Surg., 1916, p. 645.

jectile is surrounded by necrotic bile-stained liver tissue, extending a varying depth into the injured liver.

Landau has observed a very peculiar pathological condition which developed after an injury of the liver. The patient made a complete recovery from the original wound. Four weeks after the injury, when the wound had closed, the patient began to show signs of great disability and rapid emaciation. There was no icterus. The abdomen was swollen and seemed to contain fluid. Operation showed a large accumulation of slightly bile-stained gelatinous fluid in the abdominal cavity. There was no inflammation and no evidence of peritonitis. The removal of this fluid was followed by an uninterrupted recovery. Landau has called this condition cholaskos.

Treatment.—Unless symptoms due to hemorrhage are urgent the treatment must be absolutely conservative in war times. This must include absolute rest from four to six weeks. Even in those cases in which there is alarming hemorrhage, operation is usually impossible because of unfavorable conditions. If abscesses develop later they should be opened and drained under the usual conditions. If the *x*-ray shows a foreign body in the liver which seems to keep up suppuration the wound of entrance may be enlarged. On no account should a new wound of exploration be made because of the great danger of spreading infection. These cases should be kept drained for a long time so that the accumulated necrotic liver tissue may have a chance to slough away. In those cases, accompanied by severe fever, general sepsis, little can be done except in the way of supportive and antiseptic treatment. If operation is done for injury of the liver, either in civil or military practice, the same methods of stopping hemorrhage and liver suture are used which were described under Resections of the Liver.

DISEASES OF THE LIVER.

Syphilis of the Liver.—Syphilis of the liver is not of surgical importance, except where a mistake in diagnosis is made. It usually occurs during the tertiary stage of the disease in the form of either single or multiple gummata (Fig. 200). J. L. Allen collected 86 cases of gummata of the liver, in 11 of which the tumor was single. It is this form, which is frequently confused with new growths of the liver, or, if it occurs in the region of the gall-bladder, with disease of the gall-bladder. The routine use of the Wassermann test in abdominal cases will usually prevent these diagnostic errors. It is probable that a large number of primary carcinomata of the liver reported cured by excision were in reality gummata.

If an operation is done with the diagnosis of cancer of the liver the presence of scars in the liver substance will be extremely suggestive of syphilis. Syphilis may simulate portal cirrhosis, tumor of the liver, cyst, enlargement of the gall-bladder, abscess of the liver or hypertrophic biliary cirrhosis. These conditions must all be ruled out by careful examination. Gummata of the liver will nearly always respond

to antisyphilitic treatments, particularly salvarsan, the iodides and mercury. Operation is never justifiable. Syphilis may have some etiological connection with biliary cirrhosis.

FIG. 200.—Multiple gummata of liver.

Echinococcus of the Liver.—Echinococcus of the liver is an uncommon condition in most regions. In certain countries, however, particularly in Iceland, where close human companionhsip with dogs is common, the disease is not unusual. The exciting cause is the Tenia echinococcus, which has its habitat in the upper portion of the small intestine of dogs. Introduced into the intestinal canal of man the ovum undergoes partial development and may be carried to distant parts of the body. The reason for its common occurrence in the liver is that the parasites are carried from the intestinal wall through the portal circulation. The parasites set up a peculiar inflammatory reaction and become encysted in a protective connective-tissue capsule. The cyst wall consists of two layers, an outer, laminated layer, the cuticle, and an inner vascular or parenchymatous layer. Within the primary or parent cyst are generally found secondary or daughter cysts, and within these again new or so-called endo cysts develop. The scolices or heads of the parasites are found embedded in the inner walls of the

cysts. Small laminated concretions of lime salts are frequently present. Occasionally the scolices die and sterile cysts result. The cysts contain a clear serous fluid, which may be present in large or small amounts, or may be almost absent from the primary cysts. The specific gravity of the fluid varies between 1005 and 1010. It contains no albumin, and only occasionally a trace of sugar.[1]

Symptoms.—The symptoms are the result of pressure. Usually the first symptom is the presence of a tumor in the region of the liver. There may be some discomfort and sense of fulness, but rarely actual pain. If the growth is situated on the superior surface of the liver the organ will be pushed downward so that its anterior edge may reach the umbilicus, and there may be in these cases some discomfort in breathing. Usually, however, the cyst will be found springing from the inferior surface.

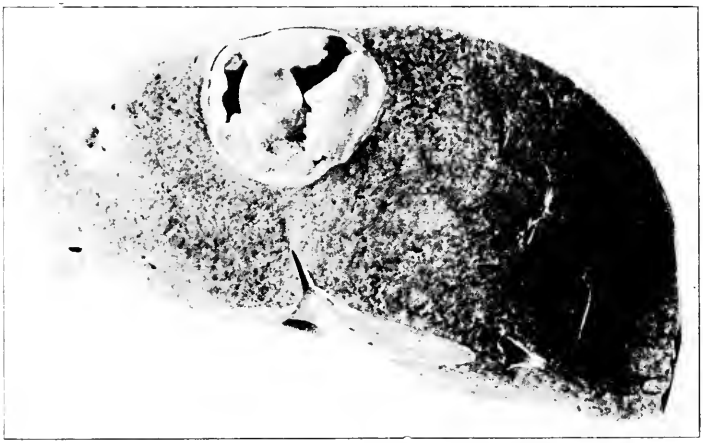

FIG. 201.—Echinococcus cyst of liver.

Diagnosis.—Hydatid fremitus which is due to the impulse of the daughter cysts upon each other in the absence of liquid in the parent sac is diagnostic. This, however, is not, as a rule present, as the parent sac usually contains fluid. Santoni, in 1894, found that the stethoscope reveals a certain peculiar sound of sonorous quality, having a low tone and of brief duration, which ceases abruptly, and which he claims is characteristic. The diagnosis is very difficult, unless something points to a definite history of contamination, such as might be expected in a country where echinococcus disease is common. Occasionally the cysts become infected, and are opened with the diagnosis of abscess of the liver.

Echinococcus cysts must be differentiated from hydrops of the gall-bladder, or if it occurs on the left side, from cysts of the pancreas. Cysts of the mesentery must also be taken into consideration.

[1] Fowler: New York State Journal, July and August, 1906.

In all these instances an *x*-ray taken after the regulation barium meal and injection of the colon, will usually, by discriminating the anatomical relations clear up the diagnosis. Hydatid cyst may also simulate carcinoma or syphilis of the liver.

Treatment.—The operations are either incision and drainage, or incision and enucleation. Incision and drainage is a very simple operation. The abdomen is opened, preferably by a transverse incision over the most prominent portion of the tumor, and the peritoneal cavity entirely walled off by gauze. An aspirating needle is introduced and the fluid evacuated. The cavity is now explored with the fingers and as much as possible of the daughter cyst and endocysts removed. The edges of the cavity are united to the parietal peritoneum and the sac packed. This is called marsupialization. The packing is continued until the cavity is obliterated by contraction. The radical removal of the cyst, though far more dangerous, is probably the preferable operation. The abdominal incision should be made large and the contents of the cyst removed, as in aspiration. The parent cyst is then enucleated by gradual traction on its wall and blunt dissection. These cases, as a rule, recover. Oliver[1] had a case of this kind which recovered. If possible the cavity left in the liver should be obliterated by deeply buried mattress sutures and a drain inserted. The soft cigarette drains are preferable, as a hard-rubber drain may induce erosion of large arterial or venous radicals, with consequent severe or even fatal hemorrhage.

In case the hydatid is situated on the upper surface of the liver it is necessary to resect one or more ribs and incise the diaphragm. The pleural cavity should be walled off by packing and the cyst removed a day or so later, when pleural adhesions have had a chance to form. Or the pleural cavity may be obliterated by suturing both layers of the pleura to the upper surface of the diaphragm, above the site selected for the incision. It is necessary during operations for echinococcus to carefully protect the wound against contamination by the cyst contents, as hydatid infection of the wound surfaces may occur. It is also wise to thoroughly disinfect the wound margins with iodin before completing the operation.

Tuberculosis of the Liver.—Tuberculosis of the liver is an uncommon affection, except as part of a generalized tuberculosis where it is common. In 476 tubercuIous subjects which came to autopsy, Simmonds[2] found tuberculosis of the liver in 82 per cent. The liver was more frequently found infected in children. There were only 2 cases of solitary tuberculosis. Elleisen, in another series of autopsies, confirmed these observations. The great majority of these cases took the form of miliary tuberculosis. The reason for the rarity of solitary or conglomerate tuberculosis of the liver is partly due to the antiseptic action of the bile and partly to the great vascularity of the liver. It is thought by some observers that the miliary tuberculosis so fre-

[1] Southern Med. Jour., March, 1911, pp. 225 228.
[2] Zentralbl. v. allg. Path. u. path. Anat., 1898, Bd. ix.

quently found in the liver is only a temporary infection, and that during the course of a general tubercular infection several crops of miliary tubercles may form in the liver and may be destroyed.

Conglomerate tuberculosis of the liver may be solitary or multiple, or in some instances they may form abscesses. It probably begins as an arterial infection or embolus, usually secondary to some focus in another part of the body. The infection spreads in the interlobular connective tissue, encroaching on but only later invading the biliary passages. As in other forms of tuberculosis, caseation and later breaking down and abscess formation results.

Lotheisen[1] collected 47 cases of conglomerate tubercle, 15 of which came to operation. In only 3 cases, however, was the correct diagnosis made before operation. In many instances when a distinct tumor can be felt the condition closely simulates carcinoma. Tuberculosis of the liver may occur at any age. Barbier discovered a large conglomerate tubercle at autopsy in an infant, aged nine months. Teitze reported 2 cases of diffuse tuberculosis of the liver occurring in children of five years. Both cases were accompanied by ascites. In both recovery followed the opening of the abdomen, the withdrawal of the fluid and a typical Talma operation.

A not uncommon sequel of tuberculosis of the liver is the development of a large abscess which frequently presents in the subphrenic space, or may even involve the pleural cavity. When this occurs the abscess should be opened, drained and packed as in any other form of liver abscess.

Diagnosis.—The diagnosis is exceedingly difficult, particularly when the tuberculoma is situated in the interior of the liver. The long-continued course of the disease and the evidence of a primary focus elsewhere are of course, suggestive. In the abscess cases, unless secondary infection has occurred, the low fever curve and the absence of a high leukocyte count may point to the condition.

The solitary tuberculoma must be differentiated from neoplasms and gummata. In the latter instance the Wassermann is of great importance. In the differentiation from carcinoma the low leukocyte count is of suggestive value, as carcinoma of the liver is almost invariably accompanied by a very high leukocytosis.

Prognosis.—The prognosis is, of course, grave, as these conglomerate tuberculoma tend to be multiple. In case a tuberculous abscess forms, the success of the treatment depends entirely on early evacuation and thorough drainage. If this is done a large number of cases can be saved. In case the abscess must be opened through the diaphragm, if adhesions between the parietal and visceral pleura have not formed, the operation must be done in two sittings.

Treatment.—In the abscess cases the treatment must not be too radical. The abscess should be widely opened and thoroughly drained and packed with iodoform gauze, in addition to which the ordinary

[1] Beitr. z. klin. Chir., lxxxi, 1.

climatic and supportive treatment of tuberculosis in general should be carried out. Solitary conglomerate tuberculoma, if accessible, should be resected. Ransohoff[1] resected a solitary tuberculoma of the liver under these conditions. The operation was not difficult, but the patient succumbed to gastric hemorrhage a few days later, probably due to a retrograde venous thrombosis.

Cirrhosis of the Liver.—Cirrhosis of the liver is primarily a medical disease. However, in certain forms surgery seems to have a definite place. The hypertrophic cirrhosis (Hanot) with jaundice has been treated in some instances by prolonged drainage of the gall-bladder. In 2 personal cases some temporary benefit was noted. However, in both cases the final outcome was fatal. In a recent case in which the gall-bladder was drained the liver was reduced to half its former size, the patient regained his strength and has remained well for a year. The atrophic cirrhosis (Laennec) accompanied by ascites has for many years come under the realm of surgery, with, however, rather meager results. The usual cause of cirrhosis of the liver is alcohol, although occasional cases occur in which an alcoholic history is entirely absent. In these cases some history of prolonged infection of one kind or another is usually present.

Pathology.—The pathology of cirrhosis of the liver is a marked overgrowth of the interstitial connective tissue. It begins as scattered areas of round-cell infiltration around the radicals of the portal vein. In the beginning the liver is somewhat enlarged and hard. The subsequent contraction of the connective tissue causes the tremendous shrinking of the liver so characteristic of the disease. This stage is accompanied by the compression and destruction of the liver tissue. Hand in hand with this destruction of liver tissue goes a new formation of liver cells, which gives the peculiar mottled appearance of the cut surface. The cut surface of a cirrhotic liver is of a granular appearance, with small areas of liver tissue projecting above the cut surfaces. In some cases the process is not equally distributed over the entire extent of the liver, but may be more marked in one or more parts. The scar formation results in a venous congestion of the radicals of the portal vein, with a hyperemia of the mucosa of the stomach and gastro-intestinal tract and a swelling of the spleen. This enlargement of the spleen is invariable. This is accompanied by the formation of ascites of a varying degree. The hyperemia of the stomach and intestinal tract may cause severe and occasionally fatal hemorrhages, although the latter are usually due to the rupture of an esophageal varix. In some cases icterus is present.

An attempt at collateral circulation always occurs: "(1) Between the accessory portal veins in the falciform ligament and the diaphragmatic para-umbilical and epigastric veins (the distended para-umbilical veins forming the caput Medusæ); (2) the veins of Retzius and the retroperitoneal veins; (3) between the inferior mesenteric and the

[1] Medical News, April, 1904.

hemorrhoidal; and (4) between the gastric and esophageal veins." (Piersol.)

Treatment.—This compensatory anastomosis was undoubtedly what suggested the so-called Talma operation to both Talma[1] and Drummond. Morrison,[2] who operated for Drummond, reported 2 cases in 1896. Talma's first operation was made in 1889, although he did not publish it until 1898. The result of the Talma operation though occasionally brilliant, is far from reliable. However, the condition of a patient with cirrhosis in which the ascites rapidly reforms after successive tappings is so hopeless that this operation should be more frequently attempted. The operation is in itself easy to perform, and carries with it the removal of the abdominal effusion. It is barely possible that the improvement of the patient is partially due to the increased nutrition of the liver through the vascular radicals, carried in the newly formed adhesions.

The abdomen is opened under general or local anesthesia above the umbilicus, to the right of the middle line or by a transverse incision. The fluid is drained away until the peritoneum is dry. The peritoneal surfaces of the liver, spleen and abdominal parietes are roughened by gauze friction or scarification, and the great omentum is extensively sutured to the parietal peritoneum. The wound must be most carefully and accurately sutured to prevent the effusion of ascitic fluid, and subsequent infection or even evisceration.

Brant, of Louisville, collected 114 operative cases, with the following result: 17, or 11 per cent., died as a result of the operation; 17, or 11 per cent., reported cured after three years; 64, or 44 per cent. were improved; 32, or 22 per cent., were dead or unimproved.

Hopfner[3] collected 700 cases in which the Talma operation was done. He believed that in the hands of capable operators in large clinics perhaps 50 per cent. of these cases can be cured, by cure meaning a permanent relief from ascites.

Out of 105 cases collected by Greeno[4] the mortality was 29.5 per cent., and only 9 showed improvement after two years. Montprofit (quoted by Moynihan) collected 224 cases, in 213 of which the results were known. The mortality was 20 per cent. Improvement occurred in 12 per cent. and recovery in 33 per cent. It is questionable, however, whether the latter can be given much credence. In a recent case of the author's, in an enormous woman weighing 300 pounds, this operation was attended by a brilliant result. It has lasted well over a year, with the patient still under observation. Naturally, with its meager successes, this operation has been extensively modified.

Lanz[5] devised a new operation, which, however, has not been adopted. His idea was to transplant the right testicle and spermatic

[1] Berl. klin. Wchnschr., September, 1898.
[2] British Med. Jour., September 18, 1896.
[3] Ergeb. de Chir. u. Orthop., 1913, Bd. vi.
[4] Am. Jour. Med. Sc., December, 1902.
[5] Centralbl. v. Chir., 1911, p. 153.

cord into the peritoneal cavity and enclose it in a bed of omental tissue. He expected that an anastomosis would occur between the veins of the pampiniform plexus and the omentum. He also justified his operation by the enormous amount of lymph channels in the spermatic cord. His first case was one of effusion, with tuberculous peritonitis, in which the effusion did not recur, in the five years during which the patient lived. At the postmortem there was seen a tremendous imbibition of the spermatic cord and retroperitoneal connective tissue, with serous effusion, a large increase in the size of vessels of the spermatic cord and an anastomosis between the spermatic veins and the branches of the vena cava. Lorentz[1] attempted this operation in 2 cases, in which the patients were completely cured after two years. This operation unquestionably seems worthy of further tests.

Kumaris[2] further modifies the Talma operation in that he denudes the renal pelvis, part of the diaphragm and fastens the omentum to the denuded areas, in the hope that the adhesions and subsequent anastomosis will be more extensive.

Aside from the Talma principles of operation two principles have recently been advanced: (1) The direct communication between the portal and systemic circulation by a von Eck fistula. This, however, is a very grave and dangerous operation and is rarely justified. Although it has been attempted by Vidol, Lenoir, Martal and Rosenstein there has been no case in which the operation has been successful. Somewhat less dangerous is the establishment of an anastomosis between the superior mesenteric and the right spermatic vein, after the method of Villard Tabernœier.

Routte attempted to drain the peritoneum through the great saphenous vein. He severed the vein 3 cm. below its termination in the vena cava, tied off the lower end and made an anastomosis between the proximal end of the vein and the parietal peritoneum. The operation, however, was not successful, and a few months afterward there was a complete obstruction of the vein. T. Morie[3] and Bernheim, of Baltimore, also attempted this operation, with like results.

The third method, which seems as simple as the Talma operation, and perhaps as efficacious, consists in the drainage of the ascitic fluid into the subcutaneous connective tissue. Several means for accomplishing this have been devised. A small incision in the peritoneum, through which a small piece of omentum is drawn and sutured subcutaneously, drainage of the peritoneum with silk threads, silver tubes, glass tubes, rubber tubes, but permanent results have not been achieved.

E. Schepelman[4] has been using for this purpose sections of blood-vessels which have been preserved in formalin. If possible pieces of human veins, which have been removed at operation for varicose veins are used. If these are not available, calf arteries seem equally effective,

[1] Wein. med. Wchnschr., 1914, lxiv, 1.
[2] Centralbl. f. Chir., 1913, p. 1916.
[3] Deutsch. Ztschr. f. Chir., vol. cxiv.
[4] Arch. f. klin. Chir., 1914–15, vol. cvi.

Under local anesthesia, to the right or to the left of the navel, a small incision is made, the peritoneum opened and the effusion relieved. One end of the hardened artery is placed inside the peritoneal cavity and the other end allowed to project into the subcutaneous connective tissue and the wound closed without drainage. He has had four cases in which, however, the result does not seem to justify the operation. Before the operation the hardened artery is soaked in water and numerous side holes are cut in it. The operation is done on both sides.

The result of all these new operations for ascites do not seem to justify the additional risks, as in no case does the result seem to equal that accomplished through the old Talma operation or one of its simple modifications, where the technic is simple, the death-rate low and the promise of some good fair. The patients submitted to operation should be carefully selected. Severe jaundice, cardiac, renal or pulmonary complications or severe emaciation must be regarded as absolute contraindications.

Abscess of the Liver.—Abscess of the liver may be divided into three general classes: (1) solitary abscess, which is usually a sequel of dysentery; (2) multiple abscess of pyemic origin; (3) multiple abscesses due to suppuration in the portal system. The most interesting, from a solitary point of view, are the solitary or tropical abscesses. The solitary abscesses may be divided again into two forms: Those due to amebic dysentery and those due to some other form of intestinal infection. The amebic abscesses are, of course, very rare, except in tropical countries, where liver abscesses are a very common complication of dysentery. Up to the past few years it was thought that the amebic dysentery was the cause of most of these abscesses and that the ameba could be isolated in a large number of the so-called amebic dysenteries. During the last few years they have isolated in dysentery a bacillus which goes under the name of Bacillus shiga, which probably forms an important etiological factor in tropical dysenteries.

M. Muhlman,[1] among 120 cases of amebic abscess, was only able to find the ameba in 11 cases. A very interesting phenomenon is that these abscesses are frequently absolutely sterile: for instance, in the above 120 cases in only 7 cases were microörganisms other than the ameba found. The abscess seems to be more of a necrosis with liquefaction than true suppuration. The abscesses are nearly always solitary, and are, as a rule, located in the right lobe. The typical tropical abscess presents three different zones: the first zone a central area of detritus, the second zone of softened liver tissue, with newly formed liver cells, the third a zone of connective-tissue cells with leukocytotic infiltration and formation of new capillaries. The contents of the abscess is typical, looking very much like anchovy paste. Some very interesting work in the etiology of amebic abscess was done by Okinschewitz,[2] He injected the amebæ of dysentery into the portal veins of various experimental animals without being able to

[1] Ziegler's Beiträge, lvii, 551. [2] St. Petersburg, 1910.

produce an abscess. Thinking that perhaps abscesses were due to the absorption of toxins, he injected amebic toxins into the portal circulation and was able to produce definite areas of softening without, however, true abscess formation.

Repeating his work, Muhlman, after damaging the liver with injections of alcohol into the portal circulation, was then able to produce real areas of liver abscess. Although the ameba is not so frequently localized in liver abscesses as was formerly thought, there is little question of the etiological connection between amebic dysentery and liver abscess, as in most cases which come to the postmortem table; distinct evidences of dysentery are found in the large intestine. Solitary abscess may also occur in the course of other intestinal disease. It is a rare complication of typhoid fever. The last case of this kind was reported by A. E. Halstead.[1] In his case the typhoid bacillus was isolated from the abscess in pure culture. In 1911 Ebits collected 30 cases of solitary abscess of the liver following typhoid. In 12 of these the typhoid bacillus was isolated. In only 8, however, in pure culture. These cases not infrequently develop some weeks after seeming convalescence from typhoid. Liver abscess is a not infrequent complication of appendicitis. However, they tend, as a rule, to assume the multiple form, and as such are not amenable to surgical intervention. However, the subphrenic abscess, which closely simulates liver abscess in its symptoms, is a very frequent complication of suppurative appendicitis, particularly of the retrocecal variety. In fact, liver abscess may follow any form of infection in the area of the portal circulation.

Tropical liver abscess may reach an enormous size. Pasley[2] reports 2 cases in which the enlarged liver almost completely filled the abdominal cavity. In one of these cases the lobe of the border of the liver extended to the pubes. Both of these cases recovered after the abscess was drained.

Symptoms.—The chief symptoms of solitary abscess of the liver are fever, pain, enlargement of the liver and symptoms of septic infection. The patients are usually in a state of great weakness and extreme emaciation. The fever runs a septic course, with wide intermission. There is usually pain located in the right hypochondrium, often extending toward the right shoulder. There is, of course, tenderness over the involved area. Blood examination shows pronounced leukocytosis with an increased proportion of the polymorphonuclear type. These amebic abscesses of the liver are occasionally complicated by brain abscess. Among 384 hepatic abscesses treated by Kartulis,[3] in Egypt, he found 11 cases of brain abscess, or about 3 per cent. Abscess of the brain as a complication of dysentery is invariably the sequel of a liver abscess. The course of solitary hepatic abscess may be either subacute or exceedingly chronic. In some cases reported the history has run over a period of three or four years. In other cases

[1] Tr. Am. Surg. Assn., 1915, xxxiii, 160.
[2] Lancet, 1915, p. 1076.
[3] Centralbl. f. Bakteriol., 1904, xxxvii, 527.

the course is rapid, with rapid emaciation and debility. The abscess may cure spontaneously by breaking through the chest wall in the axillary line, or, what is still more uncommon, there may be pulmonary involvement. That is, the abscess may rupture through the diaphragm into the pleural cavity, causing a complicating empyema.

Phelin[1] describes a case of this kind in which the liver abscess ruptured through the diaphragm into the lung and was discharged through the bronchus, with complete recovery of the patient. Thompson[2] has found that different authors estimate the pulmonary complication of hepatic abscess from 5.5 per cent. to 40.8 per cent., the latter, however, seeming ridiculously high. Of course, recovery through this means is exceedingly rare, as the patient usually succumbs to the pulmonary complication.

Abscess of the liver in infants, though uncommon, is not of exceeding rarity. Pritchard and Turner[3] found a postmortem abscess the size of an orange in the right lobe in an infant of five weeks. The bacilli coli and a Gram-positive of diplococcus were isolated.

Le Grande[4] was able to collect 112 cases of liver abscess in children; 11 were due to dysentery, 19 were traumatic, 9 of doubtful etiology and 1 influenzal. The rest followed abdominal infection, particularly appendicitis.

A very unusual case of liver abscess was described by Rolliston.[5] After aspirating an empyema the child's condition grew worse, with a fatal outcome. Postmortem showed that the aspirating needle had been forced through the pleural cavity, diaphragm and into the liver, causing an abscess, which proved fatal. It is not impossible that this accident occurs more frequently, without, as a rule, serious consequences.

The prevention of hepatic and subphrenic abscess after retrocecal appendicitis is perhaps the most important element of these cases. This is best accomplished by long-continued drainage through the flank. The onset is very characteristic. The complication usually occurs two or three weeks after the original abscess has been opened, and when convalescence seems well established. A rise in temperature with increased leukocyte count and absence of infection around the wound are always suspicious. Pain is very rarely a pronounced symptom. Percussion over the lower part of the chest reveals an area of dulness extending upward to the scapula in a convex line, with the absence of vocal fremitus and breath sounds. An *x*-ray clinches the diagnosis, showing the typical convex line. These cases, if operated on early before the abscess has reached large size and has progressed extensively into the subdiaphragmatic space, offer a fair prognosis.

The multiple abscess of pylephlebitis occurring from appendicitis or other forms of abdominal infections are invariably fatal. The course is one of typical sepsis with remittent fever, frequent chills and pro-

[1] Berl. klin. Wchnschr., 1914, li, 477.
[2] Ann. Surg., 1914, vol. lix.
[3] Proc. Royal Society of Med., viii, 339.
[4] Arch. de méd. des enfants, 1906, ix, 129.
[5] British Med. Jour., 1913, p.847.

gressing emaciation and debility. Surgical treatment here has been attempted, that is the opening of numerous foci of infection, but without result. These cases should be treated by supportive methods and stimulants. Autogenous vaccines should be used although the results have not been encouraging.

Edwin Beer in a case of this kind ligated the portal vein in an attempt to shut off the source of infection. The operation was well borne, but death ensued in a few days from sepsis. The idea, of course, is an excellent one, and was based on the ligation of the pelvic veins in cases of postpartum uterine infection. In the diagnosis of liver abscess of all kinds the *x*-ray is important.

Solitary abscess may follow direct extension of inflammation from suppuration below the diaphragm. They may be secondary to perinephretic abscess, to abscess of the gall-bladder or perforating gastric ulcers. The most common abscesses of this kind are those following retrocecal appendicitis. Here, however, the subphrenic abscess is far more common than the hepatic. These abscesses are probably due to a continuation of infection along the retroperitoneal lymph channels.

Treatment.—Although a certain number of liver abscesses rupture spontaneously, this result must never be awaited, as the majority rupture upward through the space in the diaphragm, between the ligaments of the liver uncovered by peritoneum, and so extend into the pleural cavity. The best treatment for liver abscess is the open surgical drainage, although many cases have been reported cured by Manson's method. This consists in the introduction of a large trocar, preferably through the tenth intercostal space in the axillary line, or wherever the abscess seems to point. A large drainage tube is inserted through the trocar, the trocar withdrawn and the contents allowed to flow into a bottle. This method, however, should not be used where there is opportunity for radical surgical intervention. Transperitoneal aspiration for the location of these abscesses should never be undertaken unless preparation for immediate operation has been made.

Jacobson very strongly recommends the aspiration treatment. The sheath of the aspirating needle is made of rubber tubing and is left in the abscess cavity. This is connected with an aspirator through which the pus is withdrawn whenever it reforms. After the emptying of the pus the cavity is washed out with a mild solution of sulphate of quinin, containing about 5 grains to the ounce.

Muhlman's Operation—As soon as a hepatic abscess is strongly suspected and emetin injections have failed the liver is explored as already described, and, if possible, under an anesthetic, so that this can be thoroughly done. Failing a general anesthetic, morphin, gr. $\frac{1}{3}$, and scopolomine gr. $\frac{1}{100}$, should be injected an hour before the exploration and novocain used locally. In all cases the surgeon must be prepared to evacuate the pus at once, otherwise the contents of the abscess, often under great tension, may escape into the peritoneum through the track of the needle. The skin is incised for three-quarters of an inch at the site of the puncture and the trocar and cannula four

and a half inches long and one-third of an inch in diameter is plunged into the abscess along the track of the exploring needle. As the trocar is withdrawn and pus escapes the end of the cannula is closed with the thumb until a rubber tube can be introduced. It is better for the pus not to escape too rapidly, and it is necessary to prevent the entry of the air which interferes with the siphonage. The rubber tube, which is about nine inches long and has been boiled, is somewhat larger than the cannula, so that it fits snugly into the puncture in the liver. It is necessary to stretch the tube before it can be introduced. This is done by threading it over a metal rod with a hook at one end. Two side holes are made near the inner end of the tube for better dranage. When the tube has been introduced well into the abscess, first the cannula and then the metal rod are withdrawn. About four inches of the tube now project, and the end of it is at once attached to a glass tube connected with another piece of tubing long enough to reach the bottom of a vessel on the floor near the bed. The end of the tube is weighted and kept under the surface of an antiseptic solution, otherwise proper siphonage is impossible. The tube is sewed to the skin to prevent it slipping out. Drainage is continued as long as pus escapes.

The favorite way of treating liver abscess is by direct operation. That is, an incision is made over the upper portion of the abdomen, through one of the incisions used in exploration of the gall-bladder. The best incision is probably a transverse incision through the upper part of the right rectus. If adhesions are present the abscess may be opened immediately. In case adhesions are not present the liver is drawn well into the abdominal wound at the site of the incision and well packed around with gauze. The following day, or forty-eight hours later, if the case is not urgent, the packing is removed and adhesions will be found to have formed. An aspirator is then thrust into the abscess cavity, which is followed by wide opening of the abscess either by knife or preferably by a thermocautery. The bleeding which is, as a rule, not profuse, can easily be checked by hot packs. If the bleeding is troublesome it may be checked by deep mattress sutures of catgut. The abscess cavity should be drained with cigarette drains and iodoform gauze, and if necessary washed out with a quinin solution after adhesions have formed.

The treatment of all amebic abscesses should be combined with the administration of emetin, either by mouth or preferably hypodermically, as this seems to have a specific action on the ameba.

Actinomycosis of the Liver.—Actinomycosis of the liver is rare It may spread to the liver from a primary lesion of a contiguous organ, for instance, the gall-bladder or from an actinomycosis of the pleura, extending through the diaphragm. The disease produces numerous areas of broken-down caseous material and pus. Large areas of the liver may become involved. As in all forms of actinomycosis there are tremendous adhesions between the diseased area of the liver and the neighboring organ. These cases are usually opened under the diagnosis

of ordinary liver abscess, and the subsequent course of the disease and the findings of the ray fungus point to diagnosis. The abscess cavity is irrigated with some antiseptic. Bevan recommends a 1 per cent. solution of cupric sulphate. Potassium iodid should be given in large quantities.

TUMORS OF THE LIVER.

Non-malignant tumors of the liver are infrequent and few of them are of surgical importance. Adenomata are occasionally encountered during operations on the liver and biliary passages. They are usually small and should not be disturbed. Occasionally adenomata reach a large size and require surgical removal. A case of this kind was reported by Keen. The tumor pressed on the cystic duct, causing complete obstruction. The patient made a perfect recovery. In cirrhosis of the liver, where there is always a regeneration of liver tissue, true adenomata may be formed.

Angioma at times occurs in the liver. They are, as a rule, small and found during abdominal operations. Unless they cause symptoms they should not be disturbed, as their removal may be attended by furious hemorrhage. Israel removed an angioma as large as an orange from the left lobe of the liver. The tumor caused pressure symptoms on the stomach, nausea, vomiting and severe pain. The bleeding during the operation was entirely controlled by an elastic ligature. The patient made a complete recovery.

Cancer of the Liver.—Cancer of the liver may be either primary or secondary. The primary form is exceedingly rare. Among 11,500 autopsies, Hale White found only 11 cases of undoubted primary liver carcinomas. Virchow found only 5 cases among 6000 autopsies. According to Hale White the incidence of primary to secondary carcinoma of the liver is 1 to 25; according to Hanseman the incidence is 1 to 40. Secondary carcinoma is common and usually follows cancer of the stomach or some other portion of the gastro-intestinal tract. It may spread from a neighboring organ, as, for instance, the pylorus or gall-bladder or hepatic flexure, or it may be metastatic, particularly from cancer of the large intestine. It is well known that carcinoma of the rectum is very frequently accompanied by secondary carcinoma of the liver. Secondary cancer usually takes the form of massive infiltration of liver tissue, with great enlargement of the liver. In an abdominal case the cut surface of the liver may look like mottled marble. In other cases only a few small scattered metastases are found. When the abdomen is opened for the removal of a cancer of the large bowel it is always wise to inspect the liver for metastases before beginning the operation.

Treatment.—Primary carcinomata of the liver have frequently been removed. However, up to recently there have been few cases which bear close inspection in which operation has been done for this condition. Many gummata have been removed under the mistaken

diagnosis of carcinoma. Such, for example, was the celebrated case of Luecke,[1] in which he removed the left lobe of the liver, which was subsequently shown by microscopic examination to be a gumma. One case resected by Fillipini for adenoma had a recurrence after three years.

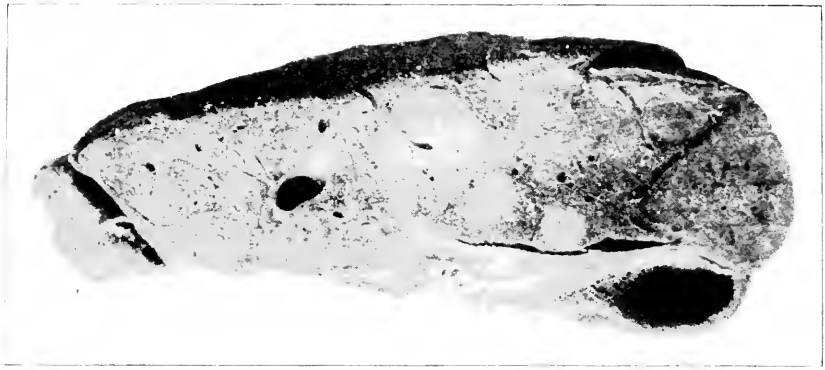

FIG. 202.—Cancer of gall-bladder and liver.

Keen, Elliott, Monks and Beck have reported resections for cancer of the liver, and in each there was recurrence after a comparatively short time. Klose[2] removed the entire left lobe of the liver for primary carcinoma. During the removal of the tumor the left branches of the hepatic artery and portal veins were tied. The patient made a complete postoperative recovery. Even more remarkable was the case of

FIG. 203.—Melanotic sarcoma of liver.

Mendel. He removed the entire right lobe for a primary malignant adenoma. The suspensory ligament was divided and the gall-bladder was lifted from its bed. During the operation the right branch of the hepatic artery was tied to the left of the cystic duct. The tumor

[1] Madelung: Mitt. a. d. Grenzgb., iii, 575.
[2] Brun's Beiträge, vol. lxxiv.

was then removed with knife and cautery, without serious bleeding, and the gall-bladder sutured in the margin of the left lobe. The patient was well a year after operation.

Primary Sarcoma of the Liver.—Primary sarcoma of the liver is rare. It may occur at any age. Two congenital cases have been reported by Van Buren Knott.[1]

Rolleston classes primary sarcomata of the liver as follows: (1) primary massive sarcoma; (2) nodular or multiple sarcoma; (3) diffuse or infiltrating sarcoma; (4) primary sarcoma arising in the cirrhotic liver. This form is rare, but 2 cases have been recorded, one by Ford[2] and one by Vecchi and Guerrini.[3] As a primary disease the occurrence of melanotic sarcoma of the liver is open to serious doubts, and it is probable that they are all secondary to some form of melanotic growth elsewhere, possibly a pigmented mole, or a small tumor of the uveal tract.

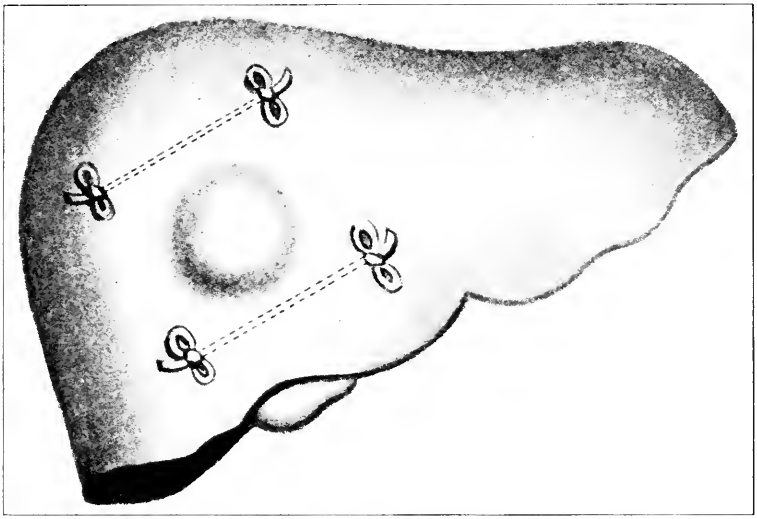

FIG. 204.—Long parallel sutures introduced as a preliminary to the excision of a tumor from the liver. (Van Buren Knott.)

Pitt reports a case of large melanotic sarcoma of the liver, supposed to be primary, as no manifestations of melanosis could be recognized during life. The postmortem, however, revealed a small growth in the right uveal tract.

Knott has collected 28 cases, including his own, of primary sarcoma of the liver which came to operation. In 9 of these the operation was merely exploratory and no effort was made to remove the tumor, which was inoperable. In 19 cases where radical excision was done there

[1] Surg., Gynec. and Obst., September, 1908, pp. 328-341.
[2] Am. Jour. Med. Sc., cxx, 43.
[3] Med. News, 1901, p. 816.

were 9 deaths. In these cases of primary sarcoma, *x*-ray medications and treatments with the Coolidge tubes may be beneficial.

Secondary Carcinoma of the Liver.—Symptoms.—The symptoms of secondary cancer of the liver are not distinctive, particularly when the primary disease has not been recognized. There is usually progressive loss of weight, emaciation and in over half the cases, jaundice. If this is not present there is, as a rule, a subicteric skin discoloration. If the tumor grows rapidly there is usually severe pain from tension on the capsule. In some instances of secondary carcinoma the primary disease may be so small as to have caused no symptoms, and the first evidence of trouble may be the occurrence of symptoms traceable to the liver. The liver may be enormously enlarged, filling a large part of the abdomen. These advanced cases are nearly always accompanied by ascites, which may often somewhat obscure the presence of the tumor. There is, of course, a loss of appetite, progressive loss of weight and marked secondary anemia.

The jaundice of cancer of the liver differs from that occurring with obstruction of the common duct, as the stools are of normal color. A very important sign in cancer of the liver, which is often overlooked, is the enormous leukocyte count, which may in some cases reach as high as 75 to 100,000. The symptoms of primary carcinoma of the liver develop more slowly than those of secondary carcinoma. The absence of a primary focus in some other part of the body is, of course, suggestive of primary carcinoma.

Diagnosis.—The diagnosis of a well-advanced case of cancer of the liver is an easy matter, as the symptoms are distinctive. However, the diagnosis of the early case is somewhat difficult. The respiratory movement of tumors of the liver is, of course, suggestive, also the position of the tumor must be taken into account. Gumma is easily differentiated by the Wassermann test. However, the possibility of the coëxistence of syphilis and cancer must not be overlooked. Cancer of the liver may be mistaken for right hydronephrosis, tumors of the stomach and hepatic flexure. These may, as a rule, be differentiated by *x*-ray examination.

Hydatid disease develops far more slowly than cancer, is usually found in early life and is not attended by the severe secondary symptoms. The treatment is purely symptomatic. In some few instances operation is warranted in primary cancers, as some cures have been reported.

Resection of the Liver.—Three principal methods have been used to control hemorrhage, which is the chief difficulty in resections of the liver. These methods are: (1) elastic ligature; (2) thermocautery; (3) suture; (4) combination of these.

The elastic ligature is only applicable in cases in which the tumor is more or less pedunculated. The abdomen is opened by a transverse incision and the rest of the abdominal cavity is protected by packing. The tumor mass is then encircled by a tight elastic ligature. After two or three days, if the tumor has not completely sloughed off,

it is removed by the knife or thermocautery. The elastic ligature may also be used as a temporary hemostatic. Often the tumor is removed and the bleeding-points controlled by other means; the ligature is removed.

(1) Pringle[1] temporarily controlled the hemorrhage by clamping the gastrohepatic omentum with a large rubber-covered clamp. The hemostasis was satisfactory. After the tumor was removed the individual vessels were ligated by transfixion. (2) In Keen's celebrated case the thermocautery alone was used. The thermocautery should not be used at a white heat, as the liver tissue should be burned through slowly. Though the thermocautery is not an ideal method of removing liver tumors, it should always be held in readiness as an adjunct. (3) Since the introduction of the Kusnetzioff blunt needles the technic of liver suture has been revolutionized. These needles, which are blunt, may be passed through the parenchyma without cutting the numerous thin-walled vessels.

The portion of the liver to be removed is surrounded by deep interlocking mattress sutures and these sutures are tightened, but not sufficiently to cut through the liver tissue. Many ingenious methods have been adopted to prevent the cutting through of the sutures. The sutures may be tied over rubber tubes, the ends of which protrude through the abdominal incision. Freeman tied the sutures over long strips of gauze, which, however, he found rather difficult to remove.

Kornew and Schaack have frequently successfully removed large masses of liver in dogs, as follows: "Take two broad strips of fascia (obtained from any convenient place on the same patient, *e. g.*, the thigh) and place them on the upper and under surface of the liver just internal to the line of proposed section. With a long rounded needle, introduce near the inner edge of the strips of fascia a row of continuous mattress sutures. These sutures are of thick catgut or silk and pass through both the fascial strips and the liver, and ought to be applied in the shoemaker fashion. After the sutures are pulled tight they are tied together at the anterior and posterior edge of the liver (cut away a portion of liver condemned). Cover the liver stump with the cuff formed by the fascia."[2]

An excellent method has been devised by Van Buren Knott: "Parallel with the wound in the liver, or with the area to be excised and about one-half inch from its edge, upon either side insert deeply through the liver substance, by means of a large, round, blunt needle, shown in Fig. 205, a strand of No. 3 catgut. These needles, as well as the small, blunt needle mentioned later, are modifications of Kousnietzoff's liver needles which have been so successfully used and have proved very satisfactory. These strands should enter the liver tissue about one inch beyond the edge of the wound, run deeply through the liver substance and emerge the same distance from the opposite end of the wound. The ends of these catgut strands are now fastened by

[1] Ann. Surg., vol. xlvii.

[2] Binnie: Operative Surgery.

drawing them up snugly and tying to either end of both small strands a small ordinary skein of catgut, which prevents the indrawing of the suture ends. Transverse interrupted sutures of No. 3 catgut are

FIG. 205.—The sunken catgut strands in the tissue parallel to the wound to be sutured. (Van Buren Knott.)

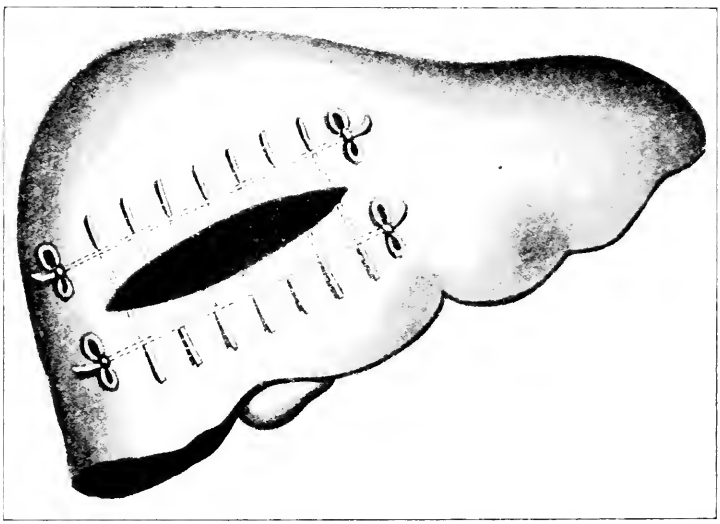

FIG. 206.—The transverse interrupted sutures introduced. (Van Buren Knott.)

now introduced by means of a small blunt needle, also shown in Fig. 206, in such a manner that they engage upon either side of the wound the buried long strand of catgut. These may be tied as rapidly

as introduced, and exerting their traction upon the buried long suture may be tied snugly (Fig. 207), ensuring hemostasis and coaptation without the danger of their cutting out.

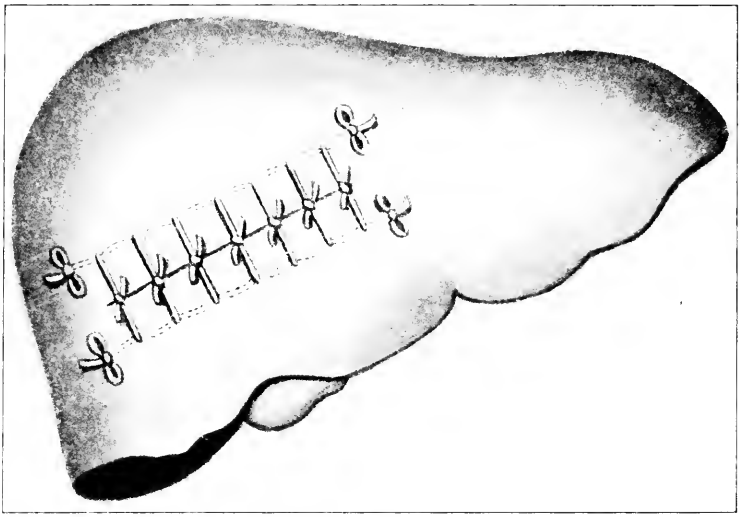

FIG. 207.—The transverse sutures tied. (Van Buren Knott.)

FIG. 208.—Secondary carcinoma of liver.

"When it is desired to remove a portion of the liver tissue carrying with it a tumor, this may be done by excising between the buried long sutures a wedge-shaped ellipse of liver substance and introducing the transverse sutures as above described.

"Hemorrhage during this procedure may be controlled either by manual pressure or by elastic ligature until the transverse sutures are tied, when it will immediately cease.

"If desired any large veins presenting along the cut surface may be tied, as recommended by Keen, by placing a ligature about them with a small needle carrying the fine catgut."

Kocher has excised liver tumors by crushing the liver tissue around the tumor with large rubber-covered clamps, which he allowed to remain in place for forty-eight hours. After their removal there was no hemorrhage. If this method is used it is wise to loosen the clamps one day and remove them the next, so as not to disturb fresh blood clots. In addition to the methods described above the ordinary means of controlling parenchymatic hemorrhage may be used in resections of the liver. The transplantation of a free strip of omentum has been successfully used by Stucke. The authors have found the application of a free strip of muscle very efficacious. If either of these methods is used the transplant should be held in apposition to the raw surface by packing. Hot water and coagulen (Kocher) may also be used. After the tumor has been removed the defect in the liver should be closed by deep catgut sutures. In order to facilitate this approximation the portion removed should, so far as possible, be wedge shaped. The abdomen should be closed except for a soft cigarette drain, which is placed over the suture line.

ANEURYSM OF THE HEPATIC ARTERY.

Aneurysm of the hepatic artery is a rare condition. In 1906 Gruenert was able to collect only 36 cases. The patients were mostly males over forty years of age. A large majority of the cases in Gruenert's[1] series (73 per cent.) were directly due to the invasion of the arterial wall by an infectious process, either secondary to an infectious process in the liver or to a septicopyemia. A very interesting case was reported by Biehart and Schuman.[2] The aneurysm was directly attributable to the invasion of the walls of the hepatic artery by a tuberculoma of the liver. In another of their cases there was an infectious process, secondary to an osteomyelitis of the tibia.

The aneurysm may be located either in the main artery or one of its primary branches. In some instances it may be intrahepatic. Syphilis and general arteriosclerosis may play a predominating role. The symptoms are more or less definite in character and resemble very closely gall-stone disease. Pain is invariable and is usually intense. It is felt in the epigastrium and is frequently of a colicky nature,

[1] Deutsche Zeitschr. f. Chir., vol. lxxi.

[2] Deutsche. Arch. f. Klin., 90.

closely resembling gall-stone colic. There may be, in addition, a sensation of fulness in the epigastrium and at times a feeling of throbbing. Jaundice is present in 60 per cent. of all cases. The jaundice is due to direct pressure on the hepatic or common duct, and is progressive, intense and unremitting, more like the jaundice of carcinoma than that of common duct stone. Hemorrhage is common, appearing from the stomach or bowel. It follows, as a rule, the erosion of the aneurysm into the common duct, the gall-bladder or the duodenum. This hemorrhage may prove fatal shortly after its first appearance. A pulsating tumor can frequently be felt in the epigastrium. Despite these suggestive symptoms the diagnosis is rarely made. The reason for this is the rarity of the condition and the fact that it is not borne in mind. G. A. Friedman[1] made a diagnosis of hepatic aneurysm before operation. The symptoms were typical. At operation Gerster found the hepatic artery dilated, tortuous and elongated. Aneurysms of the hepatic artery must be differentiated from tumors and cysts of the liver, gumma, gall-stones, cancer and duodenal ulcers.

Treatment.—In those cases following or complicating a severe sepsis nothing can be done. Up to 1903 there were only 3 cases in which operation was done for this condition. All of them resulted fatally. In 1903 the first successful case was operated on by Kehr. The diagnosis of gall-stones was made. Incision revealed an aneurysm of the right branch of the hepatic artery, which had ruptured into the gall-bladder, causing distention of the gall-bladder, jaundice and hematemesis. The aneurysm was the size of a hen's egg. The main branch of the hepatic artery was divided between two ligatures and the sac was opened and packed. The patient made an uneventful recovery. This is probably the only case in which successful operation was done for this condition.

THE GALL-BLADDER.

ANATOMY OF THE GALL-BLADDER.

The gall-bladder, pyriform in shape, surrounded below and on each side by peritoneum, is closely held in a groove, provided for it by loose connective tissue in relation with the under surface of the liver. In 4 per cent. of subjects it is entirely surrounded by peritoneum and may have a mesentery of its own. In these cases the gall-bladder may be bifid, or a septum more or less complete extends from the base toward the apex. In a few instances two gall-bladders with two cystic ducts are found. The fundus of the gall-bladder, on a lower level than its apex, when we are in the erect posture, is in relation with the abdominal wall, opposite the tip of the eighth or ninth costal cartilage.

[1] Med. Record, 1912.

Adhesions are sometimes formed here, which, as I have seen in two instances, permit gall-stones to be extruded through abscesses of the anterior abdominal wall. In other instances the gall-bladder is deeply embedded in the substance of the liver, the fundus projecting through the upper surface. In a number of cases accessory lobules of the liver have been found on the free surfaces of the gall-bladder. By its lower surface the viscus is in relation with the colon and transverse meso-

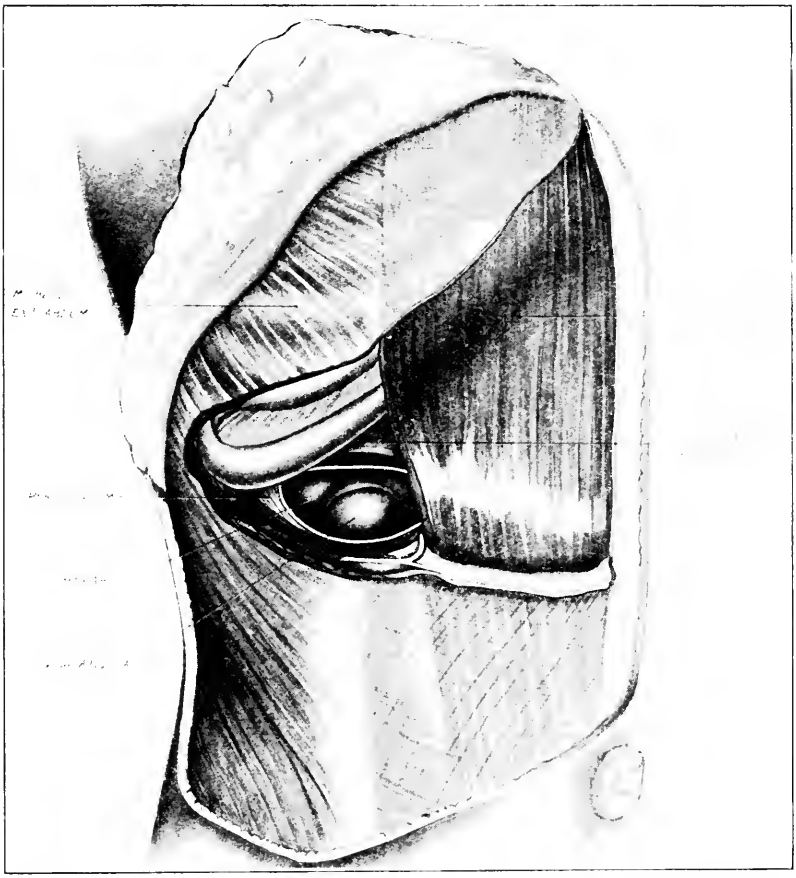

FIG. 209.—Relations of gall-bladder to anterior abdominal walls as exposed through Kocher incision. (Zuckerkandl.)

colon, the two forming a delicate shelf, which may limit infections of this region, if not too fondroyant, to the upper part of the abdominal cavity. The apex of the gall-bladder, placed on a higher level than the fundus, is in relation with the first portion of the duodenum, and even with the normal mobility of the stomach may come in relation with its pylorus.

The gall-bladder follows the movements of the liver. Its capacity

varies from one to two ounces, but may by disease be enlarged until it has been mistaken for a hydronephrosis or even an ovarian tumor.

Partly covered by peritoneum the gall-bladder has a fibrous wall with considerable admixture of muscle fiber, and is lined by a reddish mucosa during life, but this becomes bile-stained soon after death. Within the mucosa are numerous glands which secrete a clear viscid fluid which, when it accumulates in large quantities, after long continued obstruction of the cystic duct, was known to Hippocrates as "white bile." In rare cases this has been found to result from obstruction in the lymphatics at the hilum.

The neck of the gall-bladder, on a higher level than the fundus, makes a sharp turn upward and to the left and a recurve downward to the beginning of the cystic duct. In the normal condition these curves are permanent, but in distention may be somewhat straightened out. These curves, together with certain spiral elevations of the mucosa, have the function of a valve (Heister), above which stones are liable to lodge and assume a saddle form when fixed here for any length of time.

The blood supply of the gall-bladder comes chiefly from the cystic artery and in slight measure from the liver bed in which it is placed. The cystic artery derived from the right branch of the hepatic runs downward and forward along the cystic duct and usually behind it, and divides into two branches, of which the left is the larger. Its close relation to the cystic duct will explain the occlusion of the artery by an obstructing stone in the duct and account for gangrene of the gall-bladder when an infection already exists. In rare instances the main artery of the gall-bladder comes from the pancreatico-duodenal. It is then likely to be wounded in operations on the cystic or common ducts.

The cystic duct, about one and a half inches in length, runs downward and to the left, near the edge of and between the layers of the lesser omentum, where it joins the common hepatic duct to form the common bile duct. The angle of union is very oblique, the hepatic duct forming a nearly direct continuation with the common duct. Therefore, in distention of the common duct the hepatic duct is more likely to be dilated and by lateral pressure occludes the cystic duct. This, therefore, does not participate in distention of the common bile duct. Parallelism of the cystic and hepatic ducts accounts for injuries and postoperative stricture unless great care be taken during operations. The cystic duct is the narrowest of the bile ducts.

The hepatic duct, formed by the union of the larger right and the smaller left branch, is about two inches in length, and widens, as it descends to the right and in front of the portal vein, to become continuous with the common bile duct. The latter, a little over three inches in length, empties through a papilla in the lower part of the perpendicular portion of the duodenum. This papilla is at the upper end of a little perpendicular ledge and is under cover of the first transverse valve of the duodenum. As a rule the pancreatic duct empties into the duodenum through this papilla.

In its course the common duct may be divided into three portions, the relations of which are of the very greatest importance. The supraduodenal portion extends from the confluence of the cystic and hepatic ducts to the upper portion of the duodenum. It is contained within the free edge of the lesser omentum, the hepatic artery lying to the left and the portal vein behind. In the peritoneal duplicature are also contained a number of lymph nodes, the uppermost of which is situated in the hilum of the liver, and is known as the gland of Hartman. This is frequently enlarged in infections of the bile ducts, and may readily be mistaken for a neoplasm. In this part of its course the common duct can easily be palpated between the thumb and forefinger of the left hand when the forefinger is introduced into the foramen of Winslow, the back of the operator being turned to the edge of the table. In old-standing cases of cholelithiasis this method is often impracticable by reason of adhesions.

The second portion of the common duct, usually a little over an inch in length, lies behind the duodenum, between it and the head of the pancreas, or in a groove or within a tunnel of the latter. In 55 out of 58 cases Bunger[1] found the common bile duct completely surrounded by pancreatic tissue. The division of it would be necessary before the duct could be reached by any operative procedure. For direct attack this part of the duct is the least accessible.

The third or interstitial part of the duct runs obliquely through the wall of the duodenum for a distance of about three-quarters of an inch. Near its termination there is a slight widening, the diverticulum of Vater, in which stones are liable to lodgment and growth, and from which, in cases of spontaneous cure, they may ulcerate through the mucosa. The entrance of the pancreatic into the terminus of the common duct accounts for the not infrequent complication of acute or chronic inflammation of the pancreas as a sequel of primary infection in the biliary ways. The diameter of the common bile duct, except for the little ampulla of Vater, becomes smaller from above downward and is narrowest at the papilla. In its widest part it measures about one-quarter of an inch.

Surrounding the outlet of the common duct is a circular muscle, the sphincter of Oddi, and the longitudinal fibers within the duct wall are continuous with those of the gall-bladder.

Function.—The function of the gall-bladder is far from final solution. That it is not essential is evident from studies of comparative anatomy, and from the fact that it is not missed after removal for or obliteration from disease. As can be seen in the larger fowls, it possesses a rhythmic contraction. Okada[2] found that during digestion spontaneous contractions occur about two to five times per minute, the greater increase being during the height of digestion. On the other hand he has seen no contraction after an hour or more of observation.

Although the capacity of the gall-bladder is limited to one or two

[1] Beitr. z. klin. Chir., vol. xxxix. [2] Jour. Physiol., 1915, i, 42.

ounces it probably acts as a storehouse for bile during the intervals of digestion, in order that a certain quantity may be poured into the duodenum as soon as this begins to receive the first chyme discharge from the stomach. In the interval of digestion the pressure in the ducts is unequal to the task of overcoming the sphincter and bile accumulates in the gall-bladder. This is evidenced by the bile flow in drainage cases. It is greater and most annoying during the night. By a late feeding the excessive night drainage can be evaded.

That some storage function seems to be desirable in the human being is proved by the fact that secondary gall-bladders, though of small size, not infrequently form after the gall-bladder has been removed. While in the gall-bladder the bile becomes darker in color and thickened, its solid matter increases from 1 to 300 per cent.

The gall and bile ducts are supplied with nerves from the hepatic plexus, into which pass filaments from the pneumogastric.

The pain in the right shoulder, so often complained of in gall-stone colic and diseases of the liver, is due to the partial origin of the phrenic nerve from the fourth cervical, which also sends branches to the shoulder. A pain in the region of the scapula in lesions of the gall-bladder is probably a reflex, and can be accounted for through the irritation of the intercostal filaments to the diaphragm and from which the pain is reflected to the posterior dorsal cutaneous.

CONGENITAL ANOMALIES OF THE GALL-BLADDER.

Until the surgical procedures on the gall-bladder and ducts became of daily occurrence the congenital anomalies of the gall-bladder were only of academic interest. Today it is essential that every surgeon should be fairly familiar with the congenital anomalies, many of which may be encountered during an operation. Although long recognized as occurring from time to time, Kehr[1] was the first to call attention to this subject. More recently Schachner has collected a number of more recent cases, including one of his own. He has shown that anomalies in this region follow the rule obtaining elsewhere, namely, in not occurring singly.

Any anomaly of the gall-bladder may have attending it one of the peritoneal coat, of the septum or of an unusual blood supply. The gall-bladder may be double or bilobed or simply have a diverticulum. In its location it may be anomalous in being intrahepatic, left-sided or entirely floating.

Of particular importance is the intrahepatic gall-bladder, which may be partly or entirely embedded in the liver substance, and so surrounded that it can only be found with difficulty if at all. A case is recorded by Lemon, in which the fundus alone projected and in which gall-stones were found.

Deve[2] in the study of 120 livers of infants found 3 in which the

[1] München. med. Wchnschr., 1903.

[2] Bull. de la Soc. Anat., 1903.

bladders were completely embedded in liver tissue. Schacher[1] collected 7 cases of congenital absence of the gall-bladder, and Foerster states that in most of these cases the common duct is wider than normal. Examination of the cases reported shows that the bile ducts may be normal, although in a number of instances the hepatic ducts have opened seemingly into the duodenum or stomach.

Although of slight surgical interest, congenital obliteration of the biliary ducts must be noted in this place. In 1892 John Thomson was enabled already to collect 50 cases and in 1908 Lavenson collected 62 cases. Whether the result of an anomalous development or of peritoneal adhesions the result of syphilis is immaterial. These cases are recognized by a persistent jaundice, which becomes intense and is ordinarily fatal within a few months. If in these cases an exploration reveals the presence of a gall-bladder a cholecystenterostomy is indicated, and has been performed a number of times.

FIG. 210.—Choledochus cyst. (Fowler.)

Cysts of the Common Duct.—A very rare congenital anomaly is the congenital idiopathic choledochus cyst, of which Kehr collected 19 cases. One was recently reported by Russel Fowler,[2] in which the cyst was as large as an orange (Fig. 210). The condition must not be confused with dilatation of the duct from obstruction. The probable explanation of the condition is an angulation of the duct at its entrance into the duodenal wall. Most of these cases die in childhood. The diagnosis has not been made in any case. The proper operation is choledocho-enterostomy.

[1] Ann. Surg., October, 1916.
[2] Ibid., November, 1916.

WOUNDS AND PERFORATIONS OF THE GALL-BLADDER.

Rupture of a distended gall-bladder has been occasionally encountered as the result of direct violence, such as being caught between bumpers or being run over. The abdomen has usually presented injuries of which the ruptured gall-bladder was the least important. In the same way perforating wounds of the gall-bladder have been recorded as complications of other visceral injuries. Direct violence exerted upon a diseased gall-bladder has not infrequently caused its rupture and in many of the cases stone was found. McLaren reports such a case in which the tear readily admitted a finger. In another case reported by us an acute gangrene of the gall-bladder followed an injury sustained two weeks before, but had not gone on to perforation.

Most perforations of the gall-bladder and of the bile ducts are the result of diseased conditions, which cause either great distention, with thinning of the gall-bladder wall, or have been associated with the perforation of stone. In a few instances rupture has occurred during an attack of typhoid fever in which the typhoid condition of the patient precluded the making of a diagnosis. In a case reported by Mason[1] the greatly distended gall-bladder was drained in the second week of the disease. The presence of bile-stained fluid on the outside spoke for a perforation. A culture showed a pure typhoid infection. Erdman and Keen[2] collected 34 cases of primary typhoidal perforation, of which 7 were operated on, with 4 recoveries. The 27 not operated upon died.

Symptoms.—Perforation of the gall-bladder and bile ducts usually develops slowly, the diseased process being ushered in with a pericystitis, due to ulceration or even localized gangrene of the bladder wall. From the statistics of Robson, Mayo and Ochsner I may infer that in about 0.5 per cent. of gall-stone cases perforation occurs either acutely or with the formation of extracystic abscesses. As in perforative appendicitis, there are usually premonitory symptoms, indicative of something wrong with the biliary ways. When time has been given the perforation leads to abscess formation without the bladder wall, therefore not infrequently a stone is found outside the biliary tract. In other cases, however, the rupture takes place without a warning signal, and at once gives to the patient the appearance of one with a grave abdominal disaster.

The symptoms are most likely to be severe when the rupture occurs in one of the bile ducts. When the rupture occurs in a diseased gall-bladder the fact that this is often associated with occlusion of the cystic duct, only a relatively small amount of bile, pure or mixed with pus, escapes into the peritoneal cavity, which probably has already been shut off by adhesions, as already referred to. When, on the other hand, the rupture occurs in one of the ducts, usually the common, the outpour of bile is very profuse and continuous. Owing to the absence of adhesions it is more likely to be poured into the general peritoneal

[1] Surg., Gynec. and Obst., 1908, p. 362. [2] Ann. Surg., 1903.

cavity. As a sign of this, I have had an experience in two instances of calling attention to a localized jaundice strictly limited to the umbilicus and the skin immediately surrounding it. When present in suddenly arising grave abdominal conditions, this sign I believe to be pathognomonic of rupture of the gall-bladder or one of the larger ducts, with free bile in the abdominal cavity. The localized jaundice is probably altogether due to imbibition through the thinnest part of the abdominal wall, but it is possible that, owing to the relation of the round ligament to the transverse fissure, there is a retrograde flow of bile through the former toward the navel, just as the caput medusæ is produced in cirrhosis.

Lewerenz[1] was enabled to collect 60 cases from the literature. Twenty-three cases were doubtless of the gall-bladder and in 8 cases there was intrahepatic rupture of the large bile ducts. The common duct was ruptured 9 times, the hepatic duct 6 times, whereas the cystic duct was torn in only one. In the remaining cases the exact nature of the tear is uncertain.

The pathological changes which follow rupture of the biliary passages depend upon the condition of the bile. If this contains pathogenic organisms a general septic peritonitis or a localized peritonitis tending to abscess formation will follow. If the bile is sterile or nearly so a subacute peritonitis with a plastic exudate occurs, as a result of which encapsulation of the escaped bile takes place. Uhde[2] reports an autopsy in which twelve years after a ruptured gall-bladder, two cysts, containing nearly pure bile, were found.

When the patient has recovered from shock, icterus is almost sure to develop in about 65 per cent. of the cases, which is in contrast with the jaundice following rupture of the liver, of which about 5 per cent. show jaundice.

The other symptoms attending perforation of the bile passages depend largely on the condition of the effused bile. When this harbors virulent organisms a more or less diffuse and acute peritonitis results although it rarely has the rapidly fatal ending seen after perforation of the appendix. When by reason of long retention in the gall-bladder or from their initial lesser virulence the organisms pass through a perforation, there is a marked tendency to walling in of the infection and abscess formation.

Prognosis.—The prognosis of rupture of the biliary ways depends on the condition of the bile and upon the place of rupture. Tears in the common duct, and particularly in the hepatic duct, are more fatal than those of the gall-bladder, the mortality being 34 per cent., and 20 per cent. respectively.

Treatment.—In the early cases repeated tapping was followed by gratifying results, but more recently it is certain that the proper procedure in all cases in which a rupture is suspected is an exploratory laparotomy. If the rupture is in an accessible part of the gall-bladder,

[1] Arch. f. klin. Chir., lxxi, 117.
[2] Langenbeck's Archiv, xxviii, 271.

partial closure with drainage is the normal procedure. When this is unfeasible, or if the gall-bladder is diseased, as it often is, its extirpation is indicated.

In tears of the common duct the difficulties grow, particularly if the tear is in the retro- or intraduodenal part of the duct, as in one of the cases above referred to. If the rupture is not complete, drainage will suffice. If the rupture is complete a permanent biliary fistula will probably result which may terminate in death after many months unless relieved. In such cases, as has been suggested by Terrier and Auvray, a cholecystenterostomy may have to be done.

SURGICAL DISEASES OF THE GALL-BLADDER.

Cholecystitis.—Inflammation of the gall-bladder and bile ducts is most protean in its manifestation. Our knowledge of the various pathological changes to be found has been greatly increased by our study through operations on the living subject. It is proper to describe various forms of inflammation of these parts, with the distinct understanding that they are in large measure interchangeable, and that one form originally involving only the mucosa may at any time become destructive of the gall-bladder, and that *per contra*, even the severest types may by resolution disappear entirely or be changed into one involving the mucosa only. In the same way an acute process may here, as elsewhere, terminate in a chronic lesion, and this again by renewed infection or from some unknown cause may flame up into a rapidly destructive acute gangrenous condition.

Acute Catarrhal Cholecystitis.—It is exceedingly likely that this is a very common affection, consequent upon an inflammation or irritation of the duodenum, as from some indiscretion in diet or from the excessive use of alcohol. With the swelling of the papilla its lumen becomes obstructed and there is a distention of the gall-bladder, with jaundice, painless, as a rule, as the chief symptom.

Since few opportunities of studying the condition in the living have occurred the condition of the gall-bladder and biliary ways is largely a matter of conjecture. Eppinger,[1] in 1 case, fatal on the eighth day from accident, found a hyperplasia of the lymphoid tissue of the mucosa in the wall of the intestine around the common duct, and suggests that since this is analogous to the tonsil, believes that the disease may be analogous to tonsillitis. When at operation few changes may be apparent in the gall-bladder itself; an enlargement of the regional lymphatics is corroborative of the diagnosis.

When the bile in these cases is retained in the gall-bladder for any length of time and the case comes to operation there is usually found the well-known hard fine biliary sand, which consists largely of bile pigments. Most of it is contained in the apex of the bladder, but not infrequently it is closely adherent to the wall and may form nuclei of stones.

[1] Klin. Wchnschr., xxi, 480.

Suppurative cholecystitis, or, as it is often called, empyema of the gall-bladder, results from the greater virulence of the infection or from an inability of the contents of the gall-bladder to escape. It is most often associated with stones, but may occasionally be encountered without them. This is particularly true of the empyema of the gall-bladder which develops during the course of typhoid fever. If the disease occurs in a gall-bladder thereunto normal, the gall-bladder is found greatly distended, with walls softened, edematous, congested, and, as a rule, of a darkish color, shaded in severest cases to the black of gangrene. The mucosa is covered with a fibrinous, a purulent or sometimes a bloody exudate. When stones are found, ulcerations varying in extent are not uncommon. The ulcer usually is due to pressure from the stone. In rare cases the ulcer is like the round ulcer of the stomach, and like this is probably of embolic origin.

Owing to the edematous condition of the mucosa the cystic duct is almost invariably occluded. If from any reason the process develops in a gall-bladder which has harbored stone for a long time, and has therefore become thickened in its walls, the distention of the gall-bladder may be very much less; indeed, the gall-bladder may be shrunken far below its normal size. In these cases of chronic empyema it is common to find pericystic adhesions so dense that the finding of the gall-bladder may cause embarrassment even to a skilled operator. The acuter the attack the greater is the tendency to distention of the viscus. When the gall-bladder is acutely inflamed it is common to find the reddened peritoneal surface covered with flakes of plastic lymph and fresh adhesions in process of formation.

From empyema to ulcerative and gangrenous cystitis the gradation is simple and rapid. Indeed, in the acutest cases of empyema it is not unusual to find a gangrenous patch, preferably on the fundus which is farthest removed from the nutrient artery. The gangrene may be limited to the mucosa, which, in a number of cases that we have seen, was exfoliated in its entirety. In most cases, however, the gangrene involves the entire thickness of the bladder wall, although it is unusual for the entire viscus to become necrotic. Without some lesion near the cystic duct, as by an impacted stone or obstruction of the main artery, total gangrene of the gall-bladder can hardly occur.

In a man, aged twenty-one years, we saw a complete gangrene of the gall-bladder follow severe and prolonged vomiting which probably caused a twist in the neck of the gall-bladder and involved the lumen of both the duct and the artery. The S-shaped curve of the cystic duct becomes more acute and twisted, the condition being analogous to a twisted ovarian pedicle.[1] Total gangrene is a rare condition. Kehr and Körte[2] do not mention it as an independent affection. In the case above alluded to the bile in the bladder was found sterile. In this case the whole gangrenous gall-bladder was exfoliated some weeks after operation.

[1] Ransohoff, J. L.: Ann. Surg. October, 1915.
[2] Körte, 1905.

In a few cases there has been described a membranous cholecystitis in which there is formed a membrane, covering more or less of the mucosa, and which may be thrown off after a drainage operation. The membrane is not unlike that encountered in membranous colitis, and may be associated with this.

Chronic Cholecystitis.—Whereas, as already indicated, this may be the sequel of an acute inflammation of the gall-bladder. There are many cases in which the disease exists in a subacute form from the beginning and is continued to a chronic state. Whereas, as a rule, it is associated with and maintained by the presence of gall-stones, the instances are not few in which stones are not found at the time of operation, either because they never existed or had been expelled, leaving the gall-bladder in a condition of chronic inflammation. Although, in rare instances, the chronically inflamed gall-bladder may be distended, it is, as a rule, diminished in size, with walls very much thickened and rigid. The organ has lost its natural color and has become white and leathery in appearance. On section the mucosa is very much thickened, closely granular in appearance and not infrequently encrusted with minute concrements of cholesterin or calcium salts.

In a thickened gall-bladder wall microörganisms often lie dormant and the disease is quiescent for years. Whether in consequence of renewed infection or perhaps from the moving of a stone long quiescent an inflammatory process lights up acutely and many of the features of an acute cystitis return.

The cystic duct may or may not be patulous, but in any event the chronically inflamed gall-bladder rarely contains normal bile. About it there are usually more or less dense adhesions, which bind the gall-bladder to the organs with which it is in relation. The first portion of the duodenum and the pylorus are most frequently involved. This is of importance in that the binding pericystic adhesions influence the skiagraph of the barium-filled stomach, thus permitting the diagnosis of chronic disease of the gall-bladder, even if the plate is negative as to stone.

Suppurative Cholangitis.—Although suppuration within the larger bile ducts, as a rule, is associated with like disease in the gall-bladder, it occasionally develops independent of them, and on account of its great gravity merits separate consideration. Always the result of a bacterial infection ascending or descending the disease affects not only the larger bile ducts but spreads to the smaller ones in the liver tissue. Small abscesses form in the larger bile ducts and many of them may form within the liver substance itself. The bile ducts are filled with a purulent exudate; often they are dilated and the walls greatly thickened. The liver usually enlarged, on section, presents many minute abscesses, some of which may contain stones. The abscesses are always about the bile radicals. Suppurative cholangitis is most often a sequel of masked gall-stone disease, and when fully developed by its nearly always grave manifestations may obscure the primary disease in the gall-bladder.

The Etiology of Gall-bladder Disease and Stone.—Whereas, the latter will be considered under separate caption, the etiology of the two is identical. Inflammation of the gall-bladder, and particularly stones, are exceedingly rare in very young children, although small stones have been found in the newborn. Still collected 20 cases, of which 10 were in infants. In a study of 409 cases Walton[1] found no stones under the twentieth year. Although they may form in early life, they give rise to no manifestation. They are usually found between the fourth and fifth decades. Ninety per cent. of gall-stones operated upon occur in women, and it is a significant fact that the causative primary infection of the gall-bladder preëminently occurs in young married women, and in relation to some parturient period. To this fact Bettman[2] called attention from a study of 120 cases. Mayo[3] states that of all the married women who have gall-stones, 90 per cent. identify the beginning of symptoms with some particular pregnancy. The fact that during the last months of pregnancy hemorrhoids are common may help to explain this relationship. Appendicitis, typhoid fever, ulcer of the stomach and duodenum and enterocolitis, in the order named, may have as sequelæ cholecystitis and eventually gall-stones. Chiari[4] found the typhoid bacillus in the gall-bladder in 19 out of 22 cases of typhoid fever. Infections far removed from the portal circulation may likewise involve the gall-bladder through the arterial blood stream, as illustrated by the presence of the specific germs of pneumonia and influenza.

The routes taken by the inflammation are three: (1) By direct continuation of the infection through the duodenal papilla or its lymphatics. This route, I believe, is the one taken in the cases following acute gastroduodenal catarrh. That it is a possible route is shown, although the illustration is gross by the presence of round worms in acutely inflamed gall-bladders with or without the presence of a stone. While organisms, and they are rare in the duodenum, may not ascend against a normal bile stream, they may grow in an obstructed bile duct. This, notwithstanding the observation by Lippman,[5] who isolated organisms from the common duct in numbers decreasing upward. (2) Through the portal circulation and elimination with the bile, organisms of attenuated virulence may find lodgment in the gall-bladder and instigate a low-grade inflammation. For the colon and typhoid bacilli this was believed until very recently to be the route of invasion of the gall-bladder. (3) Since it was established that certain pathogenic germs show a special affinity for some particular organs and tissues and their dissemination through the arterial circulation, it can no longer be doubted that this is the principal route through which the gall-bladder is infected. Rosenow[6] has conclusively shown that streptococci and colon bacilli from acute cholecystitis

[1] Ann. Surg., 1911, p. 103.
[2] Lancet Clinic, September 16, 1916.
[3] Jour. Am. Med. Assn., 1911, lvi, 1021.
[4] Ztschr. f. Heilk., xv, 199.
[5] Microörganism, Biliar, Paris, 1904.
[6] Jour. Infect. Dis., 1916, xix, 527.

PLATE X

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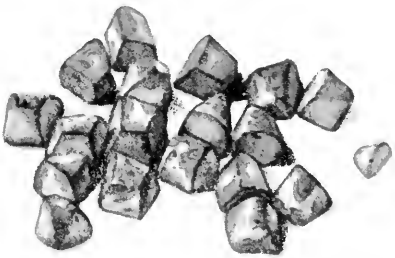

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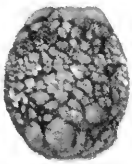

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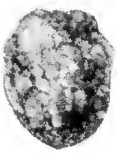

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1. Composite Gallstones, Causing Intestinal Obstruction.
2. Chronic Cholecystitis with Stone.
3. Facetted Gallstones.
4. Pigment Stones.
5. Two Crops from Same Gall-bladder.
6. Small Cholesterin Stones.
7 and 8. Common Duct Stones.
9. Vesical Calculus showing Cholesterin Crystallization.

(Illustrations Actual Size.)

intravenously injected give rise to a like disease in animals. This power to infect a gall-bladder electively may be lost by prolonged cultivation. In a large percentage of even chronic cases the deep layers of the gall-bladder show streptococci, and it is probable that this organism is the primal agent in most, though not in all, infections of this viscus and that the colon bacillus is commonly secondary. Nevertheless, this, as well as the typhoid, may through the systemic circulation, be the primary cause.

In this regard the experimental findings as to the great prevalence of the streptococcus is at variance with those of cultures from the gall-stones themselves. Since Gallipe found germs in cholelithiasis in 1886, innumerable examinations of them have been made. In a little less than 30 per cent. cultures from them are sterile, so that the epigram of Moynihan is only partly true—namely, that every gall-stone is a tombstone to the memory of the dead germs that lie within it. In their order of frequency the germs buried in gall-stones and culturable even after years are colon bacillus, typhus bacillus and streptococcus. Staphylococcus is rather unusual. Occasionally, stones from one gall-bladder, differing apparently in age, yield different cultures, showing that a gall-bladder chronically inflamed may be the seat of varying types of infection, differing from the first.

In 1898 I observed that gall-stones removed from a recent case resembled each other as peas in a pod. In old-standing cases it is often self-evident that the stones are of varying shades and evidently of different crops. The lamination of many gall-stones, in layers varying in composition, further illustrates this factor in their etiology.

Pathogenesis of Gall-stones.—They are practically all developed in the gall-bladder. Cholesterin, which is the principal constituent of most gall-stones, is not derived from the bile even when it is stagnant, but from the excessive function of the cells lining the gall-bladder when this is the seat of infection. Since there is no cholesterin-bearing mucosa in the bile ducts, cholelithiasis cannot be developed there. It is only the stone made up mostly of coloring matter that can be formed outside of the gall-bladder.

The number, size and form of stones varies enormously. To find hundreds of stones beautifully facetted and glistening is not uncommon. Not infrequently 1000 or more stones have been found, and in one case of Dr. Samuel Mixter, of Boston, nearly a quart measure was filled by 37,000 small stones. When a stone is long retained in the neck of the gall-bladder or the cystic duct it not infrequently assumes a saddle shape. Stones, in the common duct, when single are apt to be ovate or globular. Single stones of large size, made up of cholesterin with a calcium salt cortex, not infrequently completely fill the gall-bladder and assume its shape.

The chemical composition of gall-stones has been particularly studied by Naunyn, whose division of them is generally accepted.

1. Pure cholesterin stones, varying in size from a bean to that of

an olive, round or oval, with smooth surface, rather translucent and uncommonly light. When broken or on section they are beautifully glistening. Pure cholesterin stones are rare unless when very small.

2. Laminated cholesterin stones contain about 90 per cent. of cholesterin, with bilirubin, biliverdin calcium and calcium carbonate. On section they are beautifully laminated, but the external layer is ordinarily quite brittle from calcium salt content.

FIG. 211.—Gall-bladder with facetted stones. (Cincinnati Hospital Museum.)

3. The mixed cholesterin is the commonest variety and is the one usually found when there are many gall-stones. They are extensively facetted with yellow, brown or white surfaces.

4. Mixed bilirubin calcium stones which contain 25 per cent. or less of cholesterin, the remainder being bilirubin calcium. They are usually few in number and large in size, dark in color and fairly hard.

5. Pure bilirubin calcium stones are usually very small, rarely

larger than a pea. They are very solid, brown or black in appearance and occasionally become conglomerate.

Fig. 212.—Bilocular gall-bladder. (Cincinnati Hospital.)

Fig. 213.—Contracted gall-bladder with solitary stone and accessory hepatic lobule.

6. Rare stones consisting of cholesterin or pigment gravel and conglomerate stones, formed by the welding together of a number of originally small stones.

Complications.—Both cholecystitis and gall-stones may be followed by complications. In the acute cases the danger of ulceration, gangrene and perforation has already been referred to. Rare complications are to be found in the abscesses of the liver in single form, as from the ulceration of a gall-stone through the bladder wall or in the multiple form from involvement of and extension upward through the bile passages. These multiple abscesses, often minute, have likewise been alluded to. As a result of perforations, fistulæ may remain between the gall-bladder and duodenum, the transverse colon and in rare instances with the stomach. Naunyn in an analysis of 384

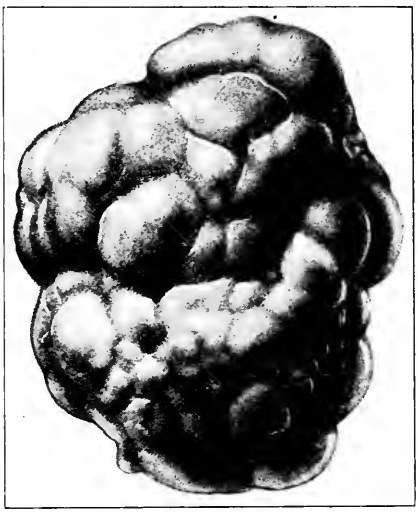


Fig. 214.—Conglomerate gall-stone, natural size.

fistulæ found 108 duodenal, and of these 93 came from the gall-bladder and the rest from the common duct. Naunyn gives 12 cases of biliary fistulæ connected with the pylorus. The rarest fistulæ are those between gall-bladder and the urinary tract, the stones passing into the renal pelvis or into the urinary bladder through a patent urachus.

Cutaneous biliary fistulæ, continuing sometimes for years, often follow gall-bladder disease. From these fistulæ there is either a mucoid discharge when the cystic duct has been obliterated, or an intermittent or continuous bile flow when the natural outlet of the common duct is obstructed from any cause. In the chronic cases, adhesions between the gall-bladder and bile ducts and contiguous

structures are very common and frequently cause symptoms after the inflammation in the gall-bladder or the gall-stones have been removed. As elsewhere, malignant disease often follows prolonged irritation from stone in the gall-bladder.

Stenosis of the common, and particularly of the cystic, duct is a very common sequel of long impaction of stone in one or the other. When a large stone ulcerates into the duodenum it may give rise to gall-stone ileus, the point of obstruction depending on the size of the stone. They measure 3 x 1 inch. In the series of 409 cases of Walton there were 13 acute obstructions, in 8 of which the previous history pointed to gall-stones.

As a complication of gall-stone disease, acute and particularly chronic pancreatitis may develop by reason of the common termination of the biliary and pancreatic ducts. Since no investigations point to the infection of the pancreas through the arterial circulation, as seems to be the case in most gall-bladder infections, it must be borne in mind that in most cases of acute and of chronic pancreatitis there is a history or at the time present disease of the biliary ways.

Symptoms and Diagnosis of Acute Cholecystitis.—Acute cholecystitis is usually inaugurated with nausea and vomiting of moderate severity and short duration. There is fever, which is low in the catarrhal state, and lasts for only a few days. Pain in the region of the gall-bladder or in the epigastrium and in the back is an almost constant symptom and with it are tenderness in the region of the gall-bladder and rigidity over the overlying muscles. The pain varies very much with the general condition of the patient. When the sensorium is involved, as in typhoid fever it may be altogether absent, therefore the condition often fails to be recognized for a considerable length of time. The pain in most cases is apt to be spasmodic with periods of intense exacerbation, doubtless due to overdistention, and muscular spasm. When the gall-bladder is much distended, it can easily be felt or percussed through the rigid muscles, but in many cases the tenderness can only be elicited by deep palpation, the examining fingers being hooked over the lower costal arch. Inhibition of respiration on that side is not an uncommon symptom. If the gall-bladder enlarges it ordinarily does so toward the umbilicus, but if there is a ptosis of the liver it may be found so low as to simulate an appendiceal abscess. In very rare cases the distention takes a backward turn and may present in the costo-iliac interval. Acute cholecystitis of the catarrhal type, when it is associated with gastro-duodenitis is attended by a painless jaundice.

Ordinarily, however, the disease is not associated with jaundice unless there is an obstruction in the common duct. The disease may go on to empyema, ulceration, gangrene and perforation without any manifestation whatever of jaundice.

Ordinarily, acute cholecystitis is not associated with very high temperatures until empyema and ulceration have resulted. The

pulse likewise remains nearly normal, as it does in many infections of the liver.

The polynuclear leukocytosis rarely exceeds 12,000 unless the disease involves contiguous structures and pericystic suppuration or extensive invasion of the small bile ducts has taken place.

The diagnosis of acute cholecystitis ordinarily offers no difficulties even when the symptoms are not very pronounced. Careful palpation will reveal a tender and enlarged gall-bladder, which can scarcely be mistaken for anything else.

Complications arising in the course of the disease can be recognized by exacerbations of pain, increased pyrexia and its concomitant acceleration of the pulse, increased leukocytosis and, if perforation be imminent, by the usual representation symptoms of localized peritonitis.

The symptoms of chronic cholecystitis are in many ways those of gall-stones, because the two conditions are, as a rule, associated. Either the inflammation begets the stones or these, by their presence cause the chronic inflammation. It is only through expert radiography that in about 50 per cent. of the subjects a differential diagnosis can be made. Nor is this necessary, since the treatment of the two conditions are the same.

Since the use of the duodenal tube of Einhorn has made it possible to obtain the secretions direct from the papilla of Vater the character of the bile may be directly studied. By such examination Einhorn diagnosticated probable cholecystitis in 40 cases by the turbidity of the bile found in the fasting condition.

Cholelithiasis.—The symptoms of cholelithiasis may be divided into two classes: (1) Those pertaining to the passage or attempted passage of a stone from the gall-bladder through the ducts, and (2) those pertaining to the quiescent periods of the disease. The first are associated with vomiting, nausea and intense pain in the region of the epigastrium, between the shoulder-blades and occasionally in the right shoulder. The pain ordinarily supposed to be due to the passage of a stone is probably not due to this at all except when the stone is very rough. Probing the bile ducts through a fistula is not, as a rule, painless. The pain of the gall-stones attack probably depends upon the acute distention of the musculofibrous coat of the gall-bladder, with spasmodic contraction of the muscular fibers. Here, as elsewhere, for example, in acute hydronephrosis, the pain is due to acute distention caused by obstruction. The acute symptoms lasting for from a few hours to as many days subside as soon as the stone has passed into the duodenum or has fallen back into the gall-bladder.

Frequently a stone may be recovered from the feces. I have found an easy way of recovering this stone to cover the seat of the toilet with a loose mesh gauze net, within which the stone is caught, as in a sieve, after the rest of the stool has been washed away by repeated flushings. This certainly is a more esthetic way of searching for gall-stones than the ordinary one of using a sieve. The passage of gall-

stones is not infrequently followed by a mild and evanescent jaundice, although in very many instances jaundice is conspicuous by its absence. Impaction for even four or five days in the common duct is not of necessity followed by jaundice. Quite recently the condition of dissociated jaundice has been recognized, in which without any tingeing of the conjunctiva an excess of bile salts may be found in the blood.

The chronic symptoms of gall-stones, except for recurring colicky attacks are very indefinite. As a rule, they are interpreted by the patient, and frequently by the physician, as due to some chronic gastric disturbance. The pain, usually in the epigastrium, comes on several hours after eating and is rarely of a severity to require medication. Tenderness, however, on deep inspiration can always be elicited by deep pressure over the gall-bladder. Enlargement of the gall-bladder is usually absent, since, as Courvoisier showed over thirty years ago, in 86 per cent. of cases in which the gall-bladder is distended the disease is malignant in character and obstructive. The cystic duct is not distensible to any considerable extent. In extreme dilatation of the gall-bladder from cancer of the pancreas the duct remains nearly of normal size, whereas the common and hepatic ducts may be an inch or more in diameter. After removal of the gall-bladder there is a distinct tendency to dilatation of the common and particularly of the hepatic duct. The recurring inflammation of the gall-bladder in cholelithiasis produces such thickening of its walls that distention does not occur.

The position of the stone can in many cases be determined by the symptoms. The most characteristic are those in which a recurring jaundice is produced by a stone in the common duct acting as a ball valve. This action was first demonstrated by Fenger. These common duct stones are often associated with rigors and high temperatures, and were formerly supposed to simulate malarial attacks, and were known as hepatic intermittent fever. The true nature of this intermittent fever was discovered by Charcot.

In many instances there is a pronounced sepsis which is in reality the clinical expression of an acute ascending cholangitis, even to the small bile ducts. It is initiated by a rigor, high fever and mental hebetude. It may be difficult to elicit any marked tenderness over the liver. The chills return irregularly. Jaundice of slight character is usually present even in the absence of calculous obstruction and may be of hematogenous origin, as it is in sepsis from other than hepatic lesions. When the jaundice is persistent, as it always is in the gravest cases, common duct obstruction may be taken for granted.

In the absence of febrile reaction the intermittent jaundice of common duct stone gravely affects the patient's general condition by the exclusion of bile from the intestine. The icterus is often attended by intractable itching, which prevents sleep. Loss of weight rapidly follows. The heart's action becomes slow and weak and the cholemia doubtless reduces the resistance of the capillary walls and the coagu-

lability of the blood thereby conducing to spontaneous hemorrhages and postoperative oozing.

Stones in the cystic duct rarely produce jaundice except when, by their size, they cause compression of the hepatic duct or swelling of the mucosa invades the common duct. There is no way in which the diagnosis of stone in the hepatic duct can be made. As a rule, hepatic duct stones are found with stones in the common duct, from which they have ascended. These stones are most apt to be overlooked in operations.

Intrahepatic Gall-stone.— In cases of cholangitis that terminate in death there are often found many minute gall-stones or accumulations of biliary sand in the liver substance. According to Beer,[1] 8 per cent. of gall-stone cases show intrahepatic stones. This, of course, refers to autopsy reports and is not true of operative cases. These stones are, for the most part, devoid of cholesterin and consist of bilirubin calcium. In other instances stones have ulcerated through the gall-bladder and found lodgment in the liver, where they usually are contained in an abscess. But in rare instances, solitary stones have been found and removed from the abscesses of the liver by operation, in which the concrement contained cholesterin. In these cases it is certain that a stone, by obstruction of the common duct, ascended through the hepatic and become lodged in one of the larger intrahepatic ducts. If active infection has not attended the process the stone may not be within an abscess cavity. Noguchi[2] has recently reported such a case in which no other stone was found either in the gall-bladder or the ducts. Intrahepatic stones, as a rule, are in the larger branches of the bile ducts, where they are, of course, inaccessible or overlooked. It is in these cases that, after operation, stones appear in the wound sometimes for weeks afterwards, very much like the boys in Yorkshire after the breaking up of Squeers's school, in *Nicholas Nickleby*. This illustrates the necessity of careful examination of the hepatic duct at every operation, and the danger of crushing a common duct stone, which may leave nuclei for the later development of intrahepatic stones.

The value of the *x*-ray in the diagnosis of gall-stones cannot be overrated. In expert hands 50 per cent. of the cases show positive shadows, and many times the exact location and even the number of stones may be demonstrable; but even in negative cases a distortion of the duodenal cap and of the pylorus and the limited mobility of the latter, as seen with the fluoroscope, indicate with much certainty the presence of stone or at least of pericystic adhesions.

The diagnosis of gall-stones ordinarily offers no difficulties, and even in the absence of positive *x*-ray findings the cases are rare in which, where stones are suspected, there is not found at operation some lesion of the gall-bladder or its passages that fully accounts for the symptoms. Ulcer of the stomach or duodenum and chronic pancre-

[1] Langenbeck's Archives, lxxi, 116. [2] Ibid., xcvi, 633.

atitis are the two conditions which oftenest might be mistaken for a chronic disease of the gall-bladder or of stone. With the proper gastric analyses and examination of the urine and of the feces, together with the adquate *x*-ray examination, an error in diagnosis is not easily made. Frequently the conditions are associated. There are few instances in which cancer of the head of the pancreas may simulate gall-stone, particularly when the disease involves its head and causes common duct obstruction. These cases are, as a rule, free from the severe pain of cholelithiasis and the jaundice, producing a recognizable gall-bladder distention, grows progressively worse without the tendency to remission shown by a common duct stone.

Prognosis.—The prognosis of gall-stones varies with the associated conditions. There can be no question that gall-stones may lie dormant in a gall-bladder practically normal, or even in one closely clinging to them and almost obliterated without producing serious results. Autopsies again and again demonstrate the innocuousness of many gall-stones. On the other hand every gall-stone is potential of serious and even grave consequences, and in view of the comparative safety of operation for its removal, should be removed. Medication probably never dissolves well-formed gall-stones that have attained an appreciable size. The only thing that can be hoped for from medication is relief from the catarrhal inflammation of the gall-bladder, which so often is present. This is perhaps best accomplished by the use of the water of some Spa, like Carlsbad, French Lick or Saratoga. The restriction of diet insisted upon at these places doubtless adds much to the efficacy of the water in preventing recurrences.

Treatment of Acute Cholecystitis.—Although this disease is always potentially surgical, it in most instances tends to spontaneous recovery by the restoration of natural drainage into the intestine. It is only when the persistence and increasing severity of symptoms point to the impending danger of empyema, ulceration and perforation that immediate surgical intervention is indicated. As a rule, this should be limited in the acute attack to gall-bladder drainage, since if it be instituted in the initial attack definite stones will probably not be found, although some biliary sand may be encountered.

In 365 inflammatory cases Mayo found stones in only 69 per cent. of the acute cases, whereas in the chronic ones stones were present in 76 per cent. In cases of very long standing stones were found in 93 per cent. However easy the removal of the gall-bladder may be in the first attack, I deem drainage preferable to cholecystectomy, since one cannot be certain of the freedom of the bile ducts from infection. For self-evident reasons, early drainage operations in the initial seizure are rarely followed by recurrence. Nevertheless, the next decade will probably see extirpation of the gall-bladder as the operation of choice, even in the milder acute type. Indeed, some surgeons have, for a number of years, advocated removing the gall-bladder during the acute attacks. Körte[1] performed it in 25 cases of varying severity with 3

[1] Körte, 1905.

deaths due to causes remote from the operation or the gall-bladder disease itself.

If the patient's condition is grave from the primary infection, such as typhoid, or from the extent and degree of local invasion, such as gangrene or perforation with abscess, a quickly performed drainage operation with protective packing is to be preferred to a radical operation, which, if it becomes necessary later, can be performed under more propitious conditions. In the hyperacute cases the judgment and experience of the surgeon must dictate how far he may safely go.

Treatment of Chronic Cholecystitis and Gall-stones.—Unless extreme age or an unusual operative risk from cardiac or renal disease contraindicates an operation, every case of chronic cystitis and of gall-stone should be made a subject of exploration and radical treatment. This statement is made with full consciousness that many patients with chronic cystitis and gall-stones live through many years and succumb to some independent affection.

Although the operation may therefore be classed among the elective, it is to be borne in mind that the less the actual necessity for interference the greater is the probability of its easy performance and safe outcome. Consequently, the difficulties, and hence the dangers of operation, increase as the demand for operation becomes imperative. Stones impacted in the cystic, and particularly in the common, duct are removed with much less certainty of success than are those from the gall-bladder. With few exceptions it may be said that every common duct stone testifies to an operation neglected. In every operation for gall-stone a choice must be made between simple cholecystostomy with drainage and removal of the gall-bladder.

Four years after Marion Sims,[1] in 1878, put cholecystostomy on a firm basis, Langenbuch advocated the removal of the gall-bladder. For thirty-five years, therefore, it has been a question as to which operation is to be preferred as the normal procedure. It is now approaching solution, very much like that of the appendix. To achieve an ideal result in cholelithiasis it is not only necessary to remove all stones, but to remove that from which and wherein they are formed, that is, the infected gall-bladder.

Gall-stone operations of all kinds are followed by a recurrence of symptoms in a little over 10 per cent. If they recur within a few weeks or a year it is reasonable to suppose, and a second operation usually reveals, a stone overlooked in the cystic, common or hepatic ducts. That this may happen to most distinguished specialists is shown by Kehr, who admits leaving stones in 19 out of 491 operations. If free stones are found in the gall-bladder at a later period they may fairly be charged to new infection. All statistics agree in the main that recurrence of symptoms is about five times more frequent after drainage than after removal of the gall-bladder. When the gall-

[1] Langenbeck's Archives, lxi, 471.

bladder is removed in animals, together with the cystic duct, there may be slight dilatation of the common and hepatic ducts, but no new gall-bladder is formed. When, however, a vestige of the gall-bladder itself or much of the cystic duct is left a repullulation of the gall-bladder may take place, and in this a stone may form.

The chief objection to cholecystectomy is its greater mortality, even in expert hands. Deaver had 36 deaths in 360 operations, whereas there were only 12 deaths following 427 drainage operations.

Since the removal of the gall-bladder is reserved for difficult cases, in many of which it probably could not be saved, and drainage operations are reserved for the more recent and therefore easier cases, it is evident that much of the excess mortality of the one operation is due to the class of cases in which it may be a necessity. If the removal of the gall-bladder were in a given series of cases to be uniformly practised in the easy and difficult cases alike the mortality would unquestionably be materially reduced below present records. Furthermore, secondary operations, in which a gall-bladder has finally to be removed, obviously become necessary.

That the operation of gall-bladder removal is more difficult than drainage should not militate against its more general adoption. The occasional surgeon may be advised in the average case to restrict his interference to drainage. It is to be borne in mind that, as Mayo has shown, the mortality after cholecystectomy in proper hands is very little if any higher than cholecystostomy with drainage.

Biliary Fistulæ.—Fistula connected with gall-bladder or common duct may be cutaneous or internal. The former, although found occasionally after spontaneous perforation of the gall-bladder, usually follows a drainage operation. Such fistulæ may be either mucous or biliary in character. If the former discharges no bile it is always due to a stricture of the cystic duct or to an overlooked impacted stone. The biliary fistula, on the other hand, indicates a patent cystic duct if the gall-bladder has not been removed, or an overlooked stone or stricture in the common duct. Cutaneous fistulæ were very common in the early history of gall-stone surgery when the gall-bladder was sewed to the skin. To obviate it the gall-bladder should not be attached too low to the peritoneum but should be attached as far upward as possible without undue tension. A complete external biliary fistula sometimes follows removal of the gall-bladder, when in tying off the cystic duct too much traction is made on the common duct and the latter is either wounded or included in the ligature.

Treatment.—The proper treatment of cutaneous mucous fistulæ is extirpation of the gall-bladder. This should not be too long delayed, since it may, by reason of adhesions, be thereby made one of the most difficult operations on the bile passages. In the very old-standing cases the subperitoneal excision of the mucosa, as first recommended by Roser, might be attempted. To be successful it would necessitate removing the entire mucosa, leaving the musculofibrous coat to become changed into a fibrous cord.

For true biliary fistulæ it is necessary to remove the cause, whether this be a stricture or an overlooked stone. They always close if there is no obstruction to the normal passages.

Stricture of the common duct, either from scar tissue or from wounds inflicted at a previous operation, is most successfully treated by a cholecystenterostomy when the gall-bladder has not been removed, although a number of operators prefer making the anastomosis with the stomach just above the pylorus. When there are many adhesions about the duodenum the stomach can more readily be approximated. When the gall-bladder has been removed a choledochoduodenostomy is indicated, provided the duct be sufficiently dilated to permit an anastomosis by suture. If the duct at a previous operation has been completely divided an end-to-end anastomosis with circular suture and drainage of the hepatic duct should be attempted, provided the field for operation can be sufficiently freed of adhesions. J. H. Jacobson[1] collected 34 cases of reconstruction of the bile ducts, 21 of which were thus treated. When it is difficult to make anastomosis because the distal end of the duct cannot be found the hepatic duct will usually be found dilated. An opening should be made into the duodenum, and into this and into the proximal end of the common or hepatic duct a rubber tube must be placed with one or two reveres in the proximal end and five or six inches of length extend through the new duodenal opening into the intestine, after the method promulgated by Sullivan.[2] Drainage, of course, is essential after all of these operations.

The internal biliary fistulæ are more numerous than the external, although they do not so appear because they do not reveal themselves by symptoms. In a study of 499 cases Courvoisier found 196 external. Of the internal there were 83 into the duodenum, 39 in the colon, 13 in the stomach, 70 in connection with abscesses of the peritoneum and 24 with the pleura and lung. Schlasinger and Eichler[3] have brought up to 47 the recorded cases of bronchobiliary fistula, in many of which gall-stones were expectorated.

In the analysis of 41 cases by Klauber[4] 26 were associated with stone. He believed that fistula develops either after the formation of a subphrenic abscess or after the direct adhesion of the gall-bladder to the diaphragm.

CANCER OF THE GALL BLADDER AND BILE DUCTS.

To avoid repetition an important factor in the pathology of chronic cholecystitis was reserved for consideration in the etiology of primary tumors. In the chronically inflamed mucosa there are quite often found papillary excrescences which, to the unaided eye, appear as papillomata projecting varying distances into the lumen of the

[1] Am. Jour. Obst., 1914, No. 6, vol. lxx. [2] Jour. Am. Med. Assn., 1909, liii, 744.
[3] Mitt. a. d. Grenzgb., xvi, 240; Deutsch. Ztschr. f. Chir., xcix, 47.
[4] Langenbeck's Archives, lxxxii, 41.

gall-bladder, and particularly into its narrow neck. Pels-Leuden,[1] and more recently the pathologists of the Rochester Clinic, have shown that careful study of many gall-bladders reveals an epithelial overgrowth in the deeper strata of the mucosa and minute papillomata on the surfaces. From these and from old ulcerations spring the cancers. Slade[2] in a careful study of 33 gall-bladders containing stones at autopsy found 30 per cent. presenting gross microscopic evidences of cancer. It is again the story of malignancy following prolonged and changing irritation from stone, infection and distention singly or combined. Cancer of the bladder is six times as common as is that of the bile ducts. Primary sarcoma are of pathological interest only, not more than 5 or 6 clear cases having been recorded. Of these, too, most were associated with stone. According to Rolliston from 4 to 14 per cent. of gall-stones develop cancer. Mayo found 4 per cent. of cancers in 1800 gall-bladder cases. That the stones are the initial factor can hardly be questioned, for in cancer of the gall-bladder they are found in from 69 per cent. according to Musser, to 95 per cent. Siegert and 100 per cent. Janowski. Gall-stones are formed in early or middle life; cancers occur only after long irritation, that is to say, rarely before fifty. Like gall-stones, biliary cancer is three times as common in women as it is in men. Furthermore, it rarely occurs when by timely drainage or gall-bladder removal the irritation has been taken away. In his very large experience, Moynihan knows of only two of his cases developing cancers after operation. If gall-stones are the cause of cancer, as has been indubitably shown, they should evidently be less common in the bile ducts. Accordingly, Musser found 100 cancers of the gall-bladder and only 18 of the ducts. In the latter the sexes were equally represented, perhaps because in my experience in proportion to the total number of gall-stone cases in each sex common duct stone occurs oftener in the male. Probably it is because of the greater rigidity and firmer fixation of the abdominal viscera in the male. In cancers of the bile ducts, stones are less frequently found—in 23 per cent. of the cases. Mayo-Robson[3] suggests that in many of them the stone probably ulcerates into the intestine. Phillips[4] recently reported 5 cases of duct cancer, each of which showed stone. Of the duct cancers about 80 per cent. occur in the choledochus and over 50 per cent. of them occur in the ampulla or the Vaterian papilla.

Biliary cancer may be of the infiltrating ulcerated type or of the fungating papillomatous type, as it appears in the urinary bladder. This type is oftenest found in the gall-bladder, whereas in duct cancers the growth often appears in the form of an annular stricture, with dense infiltration of the walls. The tumor is then usually small and very hard.

Histologically the cancer is nearly always of the cylindrical columnar cell type. Lymphatic involvement comes rather late, but the

[1] Langenbeck's Archives, lxxx, 158.
[2] Lancet, 1905, p. 1095.
[3] Tr. Clin. Soc., xx, 83.
[4] Lancet, 1913, I, 1442.

liver and head of the pancreas, especially in duct cancers, are involved early.

Symptoms.—Until a firm tumor is detected in the gall-bladder region there may be nothing to make the diagnosis certain. It may be suspected when a person with long-standing gall-stone history develops a painless and rapidly deepening jaundice without the symptoms usually attending obstruction by stone. Jaundice, of course, may be a late manifestation or rarely altogether absent when the cancer involves the gall-bladder alone. In cancers of the papilla the jaundice may be intermittent.

Cancer of the head of the pancreas may not be distinguishable from duct cancers. It is evident, therefore, that the diagnosis is rarely made except at operation or autopsy.

Treatment.—The treatment of biliary cancer is preventive. Early operation for gall-stones reduce its incidence. Only in exceptional cases can the disease, while still limited to the gall-bladder, be successfully cured by removing the gall-bladder, with perhaps an adherent and involved wedge of the liver. Cancers of the duct have been removed and the hepatic or the proximal end of the common duct implanted into the duodenum. Cancer of the papilla has been radically removed, according to Outerbridge,[1] in 22 cases, in 16 of which the duodenum was opened anteriorly; 9 of these cases died within a few days of the operation. So far as known no cases survived more than three and one-half years.

OPERATIONS ON THE LIVER, GALL-BLADDER AND BILE DUCTS.

Operations on the liver, gall-bladder and bile ducts demand the preliminary preparations usually made for abdominal section. It is especially necessary, however, to see that the stomach is emptied and that the colon, particularly, has been cleaned from above and below. A special reason for emptying the stomach is the greater tendency to acute dilatation after gall-bladder operations as compared with those on other abdominal viscera. A greatly distended colon may seriously hamper the operator by getting into the field of operation. In cases of long-standing jaundice the tendency to bleeding during and after operations must be overcome by the use of calcium chloride in 2-gram doses, three times a day, for four or five days, or preferably by the injection of 20 to 30 grams of horse serum or of diphtheria antitoxin three or four hours before operation. In a number of deeply jaundiced patients I have found the latter reduce the bleeding to the normal. Unless there is an imperative necessity, operation must be declined if there are recent petechial hemorrhages or bleeding from any mucosa. The large mortality of gall-stone surgery in its early history was chiefly due to postoperative bleeding.

[1] Ann. Surg., lvii, 414.

Since most gall-bladder operations are performed with the spine brought forward with sandbags or an appropriate table the patient should be put in the horizontal posture before wound closure is begun, to make sure that change of tension in vessels in the deeper part of the wound does not give rise to concealed bleeding. If oozing is general and not relieved by pressure it can be most successfully stopped by ingrafting a piece of muscle, taken from the wound margin, or better still a piece of omentum. Either of these placed firmly against the bleeding surface for a short time by a gauze compress will quickly stop the bleeding. The omental graft is particularly applicable in bleeding from the bed of the gall-bladder, where, after a few days, it becomes firmly adherent and by new connective-tissue growth assumes the place of the liver capsule.

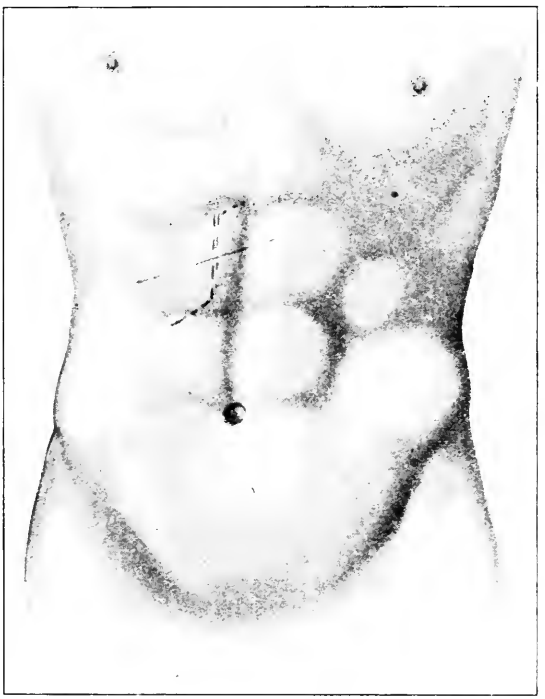


FIG. 215.— ———— transverse incision; - - - - - - - - - - Bevan incision.

Anesthesia.—Although any of the usual methods of inducing anesthesia may be used we prefer gas oxygen, expertly given, since it reduces the probability of postoperative vomiting, to which these cases are particularly liable, to a minimum. It also prevents the shock incident to the loss of heat through the prolonged inspiration of ether. Cocain and novocain infiltration may be used for simple drainage operation in cases in which a general anesthesia is not deemed safe. As a rule, it is not serviceable in operations on the deeper structures.

The combination of infiltration and gas-oxygen anesthesia, highly recommended by Crile under the name of anoci-association, is of great value in very muscular subjects to obtain complete relaxation. It may likewise help to prevent shock.

Fig. 216.—Gall-bladder dissected out in the usual way and fissure in the liver sutured.

Instruments. A few special instruments for liver and gall-bladder operations are required. They are a wide-bladed self-retaining retractor, an assortment of gall-stone forceps and scoops, a rat-tailed flexible probe, a gall-bladder spoon-ladle, a small aspirator and an assortment of small and large round needles and fish-tail and T-shaped drainage tubes. Silk suture material should be avoided, since it has frequently formed the nuclei of the recurrent stones.

Position of the Patient.—Except when in rare cases, a lumbar incision is made, the posture of the patient should be the dorsal, with the lower part of the dorsal spine raised, after the manner first suggested by Elliott. This may be done by a sand-bag six inches in diameter, or preferably by a bridge, such as is found for the purpose in every modern operating table. When properly adjusted the intestines naturally sag away from the liver and the latter can be

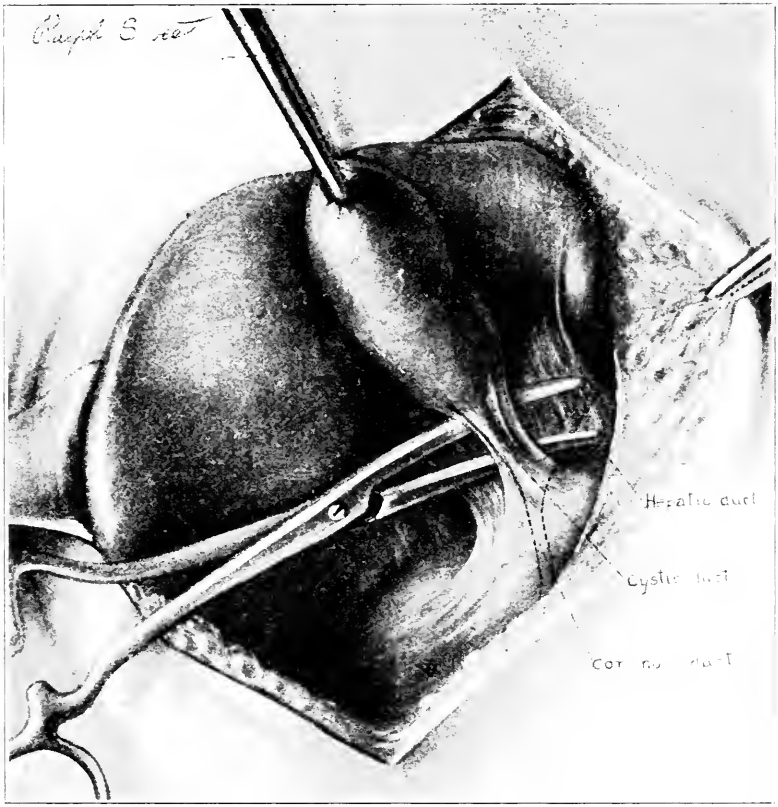


FIG. 217.—High abdominal incision, extending to ensiform if necessary. Grasping gall-bladder fundus in soft clamps, the liver is rolled out in the usual way. An additional clamp may be put on the gall-bladder near the cystic duct to retract the gall-bladder and cystic duct away from the liver, so that by blunt dissection the cystic duct and artery are separated from the surrounding tissue.

more easily turned up to expose its under surface and the bile ducts, pylorus and duodenum are brought two or three inches nearer the surface. Since so many of these operations are done in very obese individuals the importance of proper position is not easily overestimated.

Incision.—This must be planned with three objects in view: (1) it must afford adequate exposure and be large enough to admit the

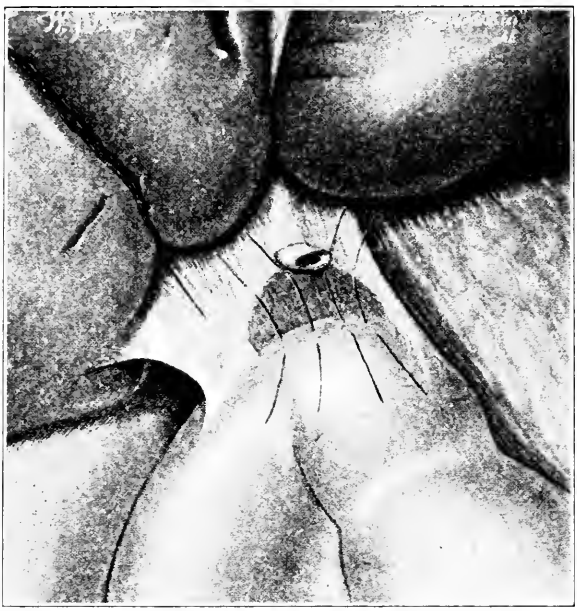


FIG. 218.—Liver raised upward. End of the hepatic duct free and sutures placed ready to draw duodenum into position. Note that gall-bladder was removed at previous operation.

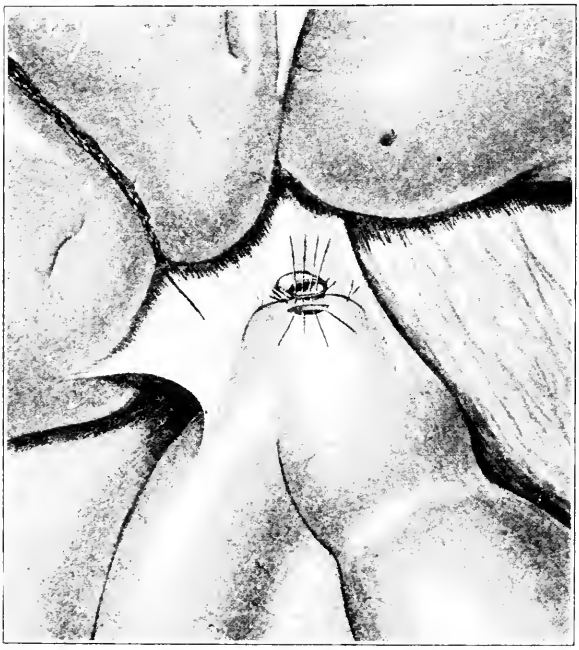


FIG. 219.—Fixation sutures tied, duodenum incised and posterior row of through-and-through sutures in place.

operator's hand, for thorough exploration of the gall-bladder, bile ducts, pylorus, head of the pancreas and duodenum; (2) it must be easily closed, and thereby (3) must be made safe as to the occurrence of a hernia by dividing as few of the terminal intercostal branches as possible. The second and third requisites are best met by a gridiron or muscle-splitting operation, like that performed in the average appendectomy. In gall-bladder work it is of little value, owing to the insufficient exposure it affords.

Most operators make a longitudinal incision through the outer third of the rectus or through the linea semilunaris, beginning an inch or more to the right and a little below the xiphoid cartilage; it extends downward for five or more inches, across the thickness of the fat layer. A long wound heals as quickly as a short wound. If it is necessary to get additional room, Bevan enlarges the incision above by dividing the rectus upward and inward, and downward and outward below, thus giving the incision an inverted Z shape. The wave incision of Kehr begins in the median line below the ensiform cartilage and extends midway to the umbilicus. It is then continued obliquely downward and outward, through the rectus to its outer third, and is thence continued downward a varying distance through the muscle. This incision I deem objectionable on account of the free bleeding and the liability to hernia.

Czerny, and later König, devised a trap-door exposure, combining a median incision with a transverse one, in the direction of the transversalis fibers, joining the former one at its lower end. Of the perpendicular incision the one in the linea semilunaris, while easy and causing least bleeding, conduces most to hernia, since there are only aponeuroses that can be approximated in the closure of the wound. All of these incisions have the further objection that especially in fat subjects, with very thin peritoneum, the wound closure is difficult, and often takes more time than the operation proper. I have found that a procedure first advised by Southers and later by McArthur overcomes this objection to a very large extent. By dividing the transversalis fascia and peritoneum transversely, wound closure is easily effected. An advantage of the perpendicular incision is that it permits relatively easy examination of the appendix, which is so often involved, even if it is not as has recently been supposed, its actual precursor. Kocher makes his incision parallel to the ribs. The incision which we have preferred for a number of years is the transverse or nearly transverse one, like that recommended by Rutherford Morrison and Sprengel. Beginning at the costal margin it extends transversely from the costo-iliac interval to the outer border of the rectus, and is continued in the same direction through this muscle as far as may be necessary. It can easily be carried across the median line to permit operation on the stomach. When the gall-bladder can be felt the outer third of the incision is laid directly over it. We have never found it necessary to place holding sutures in the rectus to prevent retraction. The divided muscle margins can easily be brought

and held together by mattress sutures. We have seen no hernia follow the transverse incision after operations either on the gall-bladder or stomach. A signal advantage of the transverse incision is that it permits, if it is desired, easy drainage through a stab wound in the loin. If carried far enough to the left it permits palpation of the spleen. The only valid objection to this incision is that in obese subjects it makes search for the appendix at times very difficult.

Ideal Cholecystotomy of Bernays. The cholecystendysis of Courvoisier was designed for the removal of gall-stones from a normal gall-bladder, with immediate closure of the incision in the latter by purse-string or layers of Lembert's suture. To many operators it seems safer to anchor the closed gall-bladder to the parietal peritoneum, and insert a cigarette drain to the angle of the wound for two or three days. Whereas some brilliant results may be achieved by this operation, which can be performed quickly and through a small incision, in view of the now accepted views of the pathology of gall-stone disease and the involvement of the bladder wall, ideal cholecystotomy must be reserved for the few cases in which stones are accidentally found in operations for other conditions in which the gall-bladder seems normal.

Cholecystostomy. The abdomen being opened through one of the incisions described the gall-bladder is looked for by sight and touch. In most cases it can be seen and felt in its usual place, and stones, if present, can be felt. In many instances, however, their presence cannot be positively made out until a later step in the operation. It must be borne in mind that the gall-bladder may be in the midline, or even to the left of it without there being a transposition of the viscera. The color and the thickness of its wall must be carefully studied, for it is only a steel-blue gall-bladder with walls that can be grasped between the fingers like a fold of skin that ordinarily should be subjected to the drainage operation when the disease is a chronic one. If the disease is of the acute type and the gall-bladder reddened, thickened and perhaps covered with fibrin flakes, it is the custom of most operators to use drainage alone, although, as already stated, the modern tendency is to extirpation.

In most chronic cases the examining finger can detect concretions from without. At this stage of the operation the ducts, the hilum of the liver and the duodenum should be carefully palpated before the gall-bladder is opened. Since in this examination one finger should be placed in the foramen of Winslow, it is well to remember that this is not a patulous opening at any time, but only an elongated slit, the margins of which are in touch until separated by the examining finger. If during this examination a stone can be felt impacted in the cystic duct a gentle effort should be made to strip it into the gall-bladder. Its dislodgment from within later may be more difficult.

Difficulties multiply when the gall-bladder is contracted and buried in adhesions. These must be severed with great care, the care increasing as the region of the ducts, and therefore of important vessels,

is approached. Unless, however, a thorough inspection or at least palpation of the field is secured the operation is incomplete, and the operator will always be justly in fear of symptom recurrence.

As the next step of the operation the gall-bladder is caught between two intestinal catch forceps and aspirated if it is distended, otherwise an incision large enough to admit the finger is at once made into it. The contents pour out at once and should be caught in gauze or an appropriate ladle which has been put in place to receive it. When there are many small stones this prevents their gliding into the peritoneal cavity. Soiling of this should be prevented as much as possible. The stones are best removed by a scoop guided by a finger on the outside of the gall-bladder. When the latter is contracted it is often bilocular with stones in each pocket, and the division of the separating wall may be necessary to evacuate the deeper one. Such gall-bladders, however, should ordinarily be removed. If a stone cannot be removed from the cystic duct without too much laceration of the mucosa the duct should be divided over the stone and drained.

A drainage tube, usually one-quarter of an inch in diameter, is next inserted into the gall-bladder and the margins of the incision fixed to it by a catgut suture. Pushing the tube into the gall-bladder and invagination of the wound margins is easily effected and maintained, by one or two Lembert sutures, or, better still, by one purse-string suture placed over another. The gall-bladder is thus made water-tight, leakage being almost impossible. The last suture should be left long for anchoring the gall-bladder to the parietal peritoneum, which step, except for the wound closure, ends the operation. This method of invaginating the gall-bladder wound is like that of Stamm-Kader in gastrostomy. When the gall-bladder cannot be brought into the abdominal parietes it is safe to drop it and surround the intraperitoneal portion of the drainage tube with gauze. It is unnecessary, and I believe harmful, although it has been recommended, to loosen the parietal peritoneum for a varying distance to meet the gall-bladder. Even when it is feasible it is unnecessary to anchor the gall-bladder to the abdominal wall. The adhesions formed may give rise to later trouble. A number of operators bring the drainage tube through a separate stab wound and completely close the original incision. Ruth[1] advises passing the drainage tube through a separate stab wound, thereby lessening the danger of the hernia. He also advises against anchoring the drained gall-bladder, since this tends to the formation of adhesions. The transverse incision obviates the necessity for a separate opening. While drainage outside of the gall-bladder is, as a rule, not indicated a cigarette drain may profitably be used when there has been much soiling of the peritoneum.

Cystocotomy.—Cystocotomy is an operation made necessary by the impaction of a stone which cannot be removed from within the gall-bladder. Generally, the stone can be felt and directly cut down upon.

[1] Jour. Am. Med. Assn., September 3, 1914.

In other instances, however, it may be necessary to split the gall-bladder along its entire length until the stone is reached. This procedure seems needlessly severe and should be reserved for extreme cases, although Terrier and Hartman recommend it even for common duct stones. If this method is followed, there can be no question as to reaching the stone. When there it is probable that stricture will follow the impaction. It is better to do a cystectomy at once. Drainage is better after opening the duct than suture, since it is improbable that the sutures will hold in the friable duct wall. Incidentally it may be stated that probably many of the reported choledochotomies are really cysticotomies over stones impacted in the lower reach of the cystic duct.

Cholecystectomy.—Earlier in this article the indications for removal of the gall-bladder were set forth. Here it is necessary, therefore, only to state when it is contra-indicated. First and foremost, when in cases in which the patulousness of the common duct opening in the duodenum is in doubt, for if this is impermeable the gall-bladder lends itself more readily to an anastomosis than either of the bile ducts. Gall-bladder excision should not be begun until the surgeon has assured himself on this point. The second contra-indication exists when there is a necessity for draining the infected bile ducts. Although this is a less positive contra-indication it is safer to act upon; however it is easily possible to drain the ducts without it. Third, cystectomy is contra-indicated in all cases in which the general condition of the patient makes a prolonged operation hazardous. In these cases a preliminary drainage will make the radical operation, if it proves necessary, a safe undertaking. The first steps of cholecystectomy are those for exposing the gall-bladder, as already described. To remove this organ one may begin at the fundus, gradually separating it from its liver bed after dividing the peritoneum on each side. It is best to do this by sharp dissection. The gall-bladder is slowly freed until the cystic duct is freely exposed. The artery and duct are tied together and divided between two forceps. When drainage is desirable it may be possible to tie the cystic artery or its two branches separately and fix a drainage tube over the stump of the duct.

A better method of removing the gall-bladder, doubtless, is that of the Rochester Clinic, in which after the liver is tilted by traction with forceps on the fundus the dissection is begun by the exposure of the cystic duct at its junction with the common duct. By traction on the neck of the gall-bladder this and the cystic duct are straightened out and a curved forceps may readily be pushed underneath the duct and artery, so that they may be lifted away from the liver. The duct and artery are clamped and tied off together. A second clamp is then applied to the distal end of the duct and used as a tractor, the gall-bladder being slowly separated from the liver from its apex to the fundus. The oozing, if it does not yield promptly to compression, quickly ceases if a muscle, or preferably an omental graft, be held in place for a few minutes with a gauze compress. While gauze packing

will control the hemorrhage it may be dangerous, as a severe secondary hemorrhage may follow its removal. We have seen this occur on the tenth day. The operation is completed by suturing the cut edges of the peritoneum in a manner to cover the denuded surface of the liver.

Owing to the frequent parallelism of the cystic and hepatic ducts, and particularly the danger of drawing the common duct into the ligature, it is safer in cholecystectomy to leave more than is actually necessary of the cystic duct than to remove too much. If drainage is desired the stump of the duct is left open and a drainage tube anchored over it with a catgut suture. In every case some drainage of the wound is to be secured.

In removing the gall-bladder there are two special dangers: (1) bleeding from a poorly placed ligature about a cystic artery, and (2) inclusion in the ligature or wound of the common duct. G. Wright has especially emphasized this danger. To avoid, the artery should be tied by itself and the duct either remain untied or be tied with readily absorbable plain catgut. If there is any doubt as to the holding of a ligature the artery may be held in a clamp forceps for a day or two. Mayo has wisely suggested that the clamp be opened for a day before it is finally removed, lest its immediate removal start bleeding afresh.

Choledochotomy.—This operation, probably first performed by Marcy, of Cambridge, in 1882, was introduced into Germany by Langenbuch and Kümmel and into England by Knowsly Thornton. The operation is indicated for stones in any part of the common duct and for drainage in cases of cholangitis. For purposes of exploration the duct may be made accessible in any of its three portions. That is to say, (1) in the supraduodenal part, (2) in the retroduodenal portion and (3) in the intramural portion of the duct. It is most accessible, of course, in the first part. The duct is exposed through the usual incision, which must here be made adequate. It is essential next to rotate the gall-bladder, by traction on the gall-bladder or properly applied gauze pads, in order to bring the common duct as near the surface as possible. The duct lies here in front of and on the outer portion of the large portal vein, and, therefore, although this should be carefully avoided, there is really very little danger of wounding it. The duct, together with the portal vein, is now lifted with the index finger of the left hand and placed in the foramen of Winslow. At this step there is frequently a very decided drop in blood-pressure, which, as we have shown experimentally and clinically, is entirely due to traction or compression of the portal vein by the examining finger. The stone is caught, if possible, between the thumb and the finger and an incision made directly over it. If the stone is not impacted it may be quite elusive and then an incision must be made longitudinally into the duct, sufficiently large to admit the examining finger. Since in most of these cases the duct is quite distended this usually is easily done. With the finger from without or appropriate scoop or forceps the stone is removed. In every case it is essential to search for concrements in the hepatic ducts and likewise to determine by

probing that the papillary orifice is patent. It is usually possible by the supraduodenal choledochotomy to remove stones from the lower reaches of the duct. Depressing the duodenum with gauze packs helps to expose more of the duct. The operation may be completed by suturing the incision, although, as a rule, since these cases are infected, it is safer to drain. A fish-tail tube may be placed directly into the common duct, but it is better to buttonhole it an inch or two from its end and insert this into the hepatic duct, thus instituting a "hepaticus drainage," which German surgeons particularly have insisted upon so much. A very satisfactory tube for this purpose is a T-shaped soft-rubber tube the size of a No. 12 English catheter. Even when the duct wound is sutured, drainage is necessary.

Retroduodenal Choledochostomy.—It is only when a stone cannot be removed through the operation just described, and this is rarely the case, that the second portion of the duodenum must be exposed and incised. This is accomplished with varying ease or difficulty, as the case may be, by loosening the duodenum through an incision one and a half or two inches, carefully made through the reflexion of the peritoneum from the duodenum to the posterior abdominal wall. By gentle traction on the descending portion of the gut this is easily drawn to the left until the common duct is reached. As will be seen (Fig. 221) this position of the duct may be surrounded by pancreatic tissue or be contained in a groove. Dissections through this must be carefully made to reach the duct. Bleeding from small pancreatic vessels may be difficult to check. When the stone is reached it is removed as in the previous operation. Drainage here is best maintained through a lumbar stab.

When the colon is closely adherent to the duodenum it is safer, for self-evident reasons, to begin mobilizing the latter by an incision to the outer side of the colon, since one cannot foresee the extent to which the duct may be buried in pancreatic tissue. One may have to abandon the duodenal mobilization operation for a transverse duodenal one. Indeed, it is questionable whether the operation should not be abandoned for the former as soon as it becomes evident that the stone cannot be reached without too extensive dissection, necessary to lift the duodenum and head of the pancreas.

The transverse duodenal choledochostomy was devised and first performed by McBurney in 1891. Its preferable indication is for common duct stone, immovably impacted in the ampulla, the intramural or the retroduodenal parts of the duct. A more worthy advantage of the operation is its leaving a patent duct lumen large enough to preclude closure at any time from scar contracture.

When in an operation it becomes evident that a stone cannot be reached or removed from above, the finger introduced into the foramen of Winslow lifts the lower part of the duct, with the stone and the duodenum, as near as possible to the abdominal incision. The anterior wall of the duodenum is then incised in its axis, for an inch or an inch and a half, and the duodenum is then incised from the papilla,

if this is readily found, or, as is most often feasible, the incision is made directly over the stone. According to Hancock the former operation, including the suturing of the intestine, should, if possible, be done with one finger in the foramen. It is unnecessary to sew the gut in the posterior wall of the duodenum. It might, indeed, prove harmful. This operation is likewise the natural one for the removal of the pancreatic stone and for growths of the papilla. Hancock[1] collected 62 cases of transverse duodenal choledochostomy, with a mortality of 12.6 per cent. The operation was done fifty-seven times for common duct stone, with a mortality of 8.7 per cent.

Cholecystenterostomy—Cholecystgastrostomy.—One or the other of these operations is indicated whenever there exists an impermeable stricture of the common duct from whatever cause, which obstruction cannot be radically relieved. Impacted stones formerly considered justifiable for the operation should no longer be considered an indication. Inoperable carcinomata of the common duct, or of the papilla or complete destruction of the common duct, when the plastic operation is unfeasible, are proper cases for an anastomosis between the gall-bladder and the alimentary canal. In cancer of the pancreas the operation can be quickly performed, and although followed by a large mortality, will often relieve the intense itching caused by the jaundice. Choice must be made between attaching the gall-bladder to the duodenum, the hepatic flexure of the colon and the stomach. The duodenum has until recently been most frequently used for the anastomosis, and next to it the hepatic flexure of the colon. Other things being equal the bile should be deflected into the duodenum or upper part of the small intestine or the stomach rather than into the hepatic colon, although by reason of its position this part of the intestine often lends itself to the quickest operation. For this reason some operators, like Mayo-Robson and Bland-Sutton recommend the colon as first choice.[2] The evident objections to filling the colon are that the action of the bile on the digestive function of the small intestine is lost and that there is doubtless a greater danger of infection of the gall-bladder and ducts. In malignant disease of the pancreas we believe this route should be used as a routine method, since the tenure of the life of the patient is at best rather short.

Although the duodenum has until recently been prefered for biliary anastomosis there are objections to it. It is often difficult and time-consuming on account of its immobility from adhesions. Unless the anastomosis is perfect there is danger of a high intestinal or pancreatic fistula, the distressing accompaniments of which it is difficult to relieve. For this reason, and because it is easily reached, the stomach just within the pylorus lends itself best to the anastomosis. The presence of bile in the stomach has been proved innocuous both by experiment on animals and by ample clinical observation. Wickhoff and Angelsberger[3] were the first to perform cholecystogastro-enterostomy on the

[1] Am. Surg., xliii, 69.
[2] Stewart, G. D.: Buck's Surgery, viii, 270.
[3] Berl. klin. Wchnschr., vi, 138.

living. Jacobson[1] collected 17 cases from the literature, exclusive of those of Kehr, who performed the operation sixty-two times.

For the retrocholecysto-enterostomy a portion of the jejunum, ten or twelve inches from its beginning, is sought and brought through a rent in the transverse mesocolon and placed in apposition to the gall-bladder. The operation is the analogue of the posterior gastro-enterostomy. Its advantages are not apparent.

Whatever the type of operation the procedure is the same. An opening one inch long is made in the gall-bladder. This is emptied, and to prevent a further outflow of bile the opening is plugged with a strip of gauze. An incision of the same length is then made down to the mucosa of the part of the stomach or intestine selected. The serous coverings of the structures are then united by a continuous catgut suture. The mucosa is next divided and united to the mucosa of the gall-bladder around the entire circumference of the opening. The operation is completed by an anterior serosa suture. A strip of omentum may be used to further prevent leakage.

Choledocho-enterostomy.—This operation is usually called for when there is an obstruction of the duct and the gall-bladder has either been removed at a previous operation or is in a shrunken state and unavailable for purposes of anastomosis. In either condition in the absence of biliary fistula the common duct is greatly dilated and may be used in the same manner as the gall-bladder for anastomosis. The first successful case was reported by Sprengel, 1891, although Redel had a fatal case ten years before. The operative technic is like that of cholecystenterostomy.

The frequency with which the removal of common duct stones is followed by symptom recurrence from papillary stenosis and prevalent biliary fistula moved Sasse[2] to advise performing choledochoduodenostomy before the first operation when there is any question of the patency of the duct. He reports 10 successful cases treated in this manner. In only 1 case did death follow from malignant disease a year after the operation.

To determine the patency of the papilla, normal salt solution should be easily injected into the intestine. Probing alone will not answer. If successful, immediate choledochoduodenostomy obviates the necessity of the second operation, as self-evident advantages of choledochostomy with drainage, as it is ordinarily performed.

Reconstruction of the Common Bile Duct.—It has already been stated that a persistent biliary fistula with acholic stools after an operation means an obstruction of the common duct from stricture, overlooked stone or inclusion of the duct in the ligature, during cystectomy. If the latter fault in technic is recognized at once a repair operation should follow. Therefore, every gall-bladder removed should be carefully examined to this end. Unfortunately, the condition is not generally recognized until many days or weeks later, when the persistence of a fistula raises a suspicion.

[1] Am. Jour. Obst., lxx, 874.

[2] Langenbeck's Archives, c, 967.

FIG. 220.—Fascial transplant sutured to peritoneal surface of bile duct.

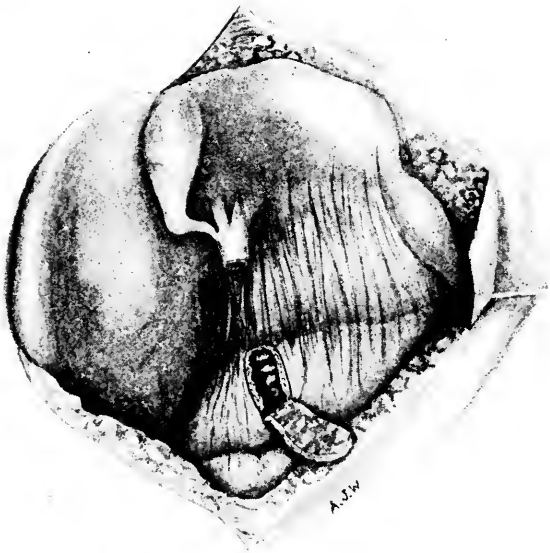


FIG. 221.—Showing duct divided and opening made into duodenum. (Walton.)

There are several methods of procedure to reëstablish the flow of bile into the duodenum.

Direct Implantation.—This method is doubtless the one of choice when a direct end-to-end anastomosis is impracticable on account of the long gap between the ends of the divided duct or because the distal end of the duct cannot be found. In old-standing cases this is the rule and no prolonged search for it should be made. Direct implantations were first made by W. J. Mayo for a variety of causes. When the common duct has been removed for disease the hepatic duct lends itself to direct implantation. The duodenum may have to be mobilized or perhaps a loop of the jejunum may have to be brought into relation with the duct. A partially covered portion of the intestine may be chosen to ensure the success of the union.

Reconstruction by autogenous grafts or rubber tubes has been successfully practised in experiments on animals and quite often on the human being. Among the structures used to supplant the common duct, sections of veins and the appendix have been instituted. It is not likely that permanent benefit will arise from these substitutes, since the veins easily become obstructed and the appendix will be found unfeasible because it is itself diseased. Much more promising are the fascial transplants which experimentally have been used (Lewis and Davis[1]). In a number of instances they have held in the human being. Ginsberg[2] has recently reported a case of this kind in which, after the fourth operation, the grafts held about a rubber tube. The grafts are anchored to both ends of the duct, or to the duct above and an opening in the intestine below.

A. G. Sullivan[3] has described a method of reconstruction by the use of a rubber tube which has proved satisfactory in the hands of quite a number of surgeons. To secure success his method should be accurately followed: "Into the stump of the hepatic duct an elastic rubber tube is inserted for about half an inch and securely sutured to it with several unabsorbable sutures. The other end of the tube is pushed down into the duodenum through the stump of the common duct if possible, or if this is not possible, the tube should project through a small incision in the anterior wall of the duodenum about one-half inch into its lumen.

"The opening in the duodenum should be sufficiently repaired so that the cut edges snugly encircle the tube. At the point where the tube penetrates the intestinal wall the tube should be firmly anchored to the duodenum with unabsorbable sutures. The duodenal walls are then sutured over it so that for a distance of about 2 cm. before the tube penetrates into the intestine it runs in a canal composed of overlapped duodenum. The tube is then anchored with unabsorbable suture in several places to the duodenum and the gastrohepatic

[1] Tr. Western Surg. Assn., 1913.
Jour. Am. Med. Assn., 1912, p. 2026.

[2] Ann. Surg., January, 1917.

omentum. In short, the tube is put in with the idea of keeping it *in situ* as long as possible. The great omentum is then drawn up

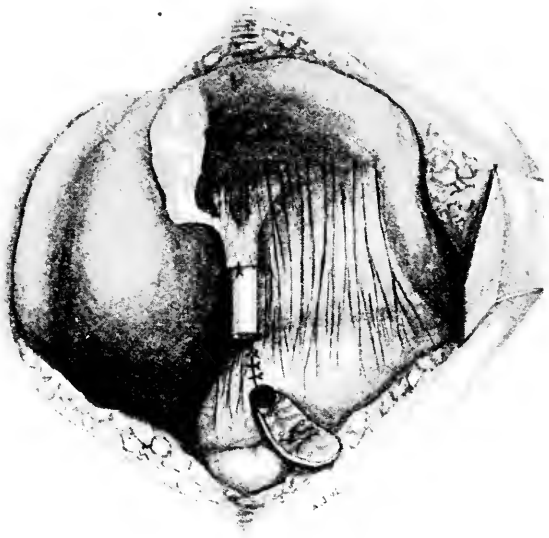


FIG. 222.—Tube sutured in duct; opening in duodenum partly sutured. (Walton.)

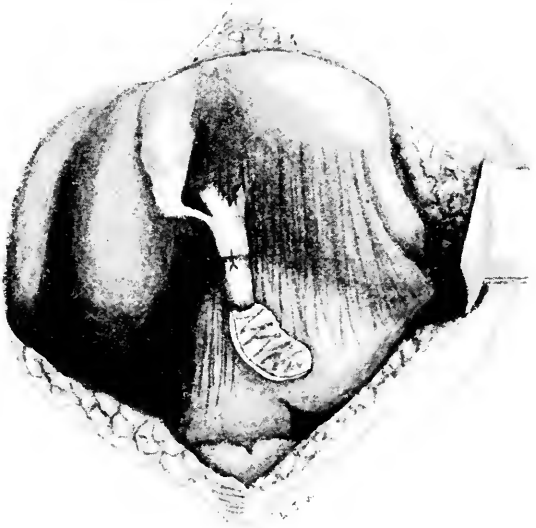


FIG. 223.—Tube inserted into duodenum drawn up as close as possible to common duct. (Walton.)

and suitable area is selected with which to cover the exposed surface of the tube. The area is traumatized by drawing a dry sponge over it lightly a few times; similar friction is applied to the duodenum and the gastrohepatic omentum on either side of the tube. The omentum is then placed so as to cover the tube and extend beyond it 1 or 2 cm. in all directions, and is carefully anchored in position by several catgut sutures."

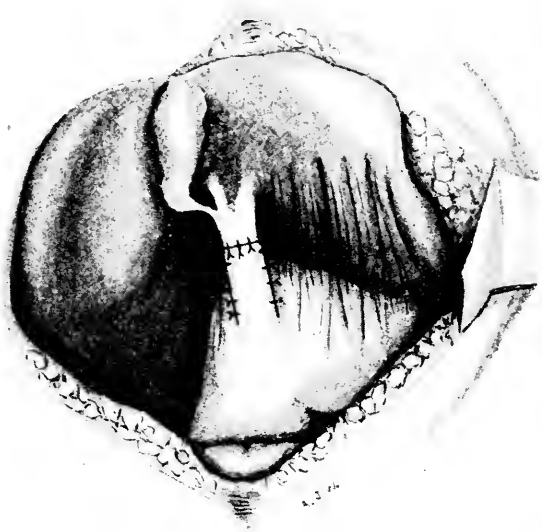


FIG. 224.—The duodenal flap sutured around the rubber tube. (Walton.)

A very excellent suggestion for the reconstruction of the common duct and lining it with mucosa has been made by Stubenrauch[1] and amplified by Walton, as shown in Figs. 222, 223 and 224. A section of the duodenum is made with a pedicle below, which section is placed about a rubber tube and finally anchored to the proximal end of the duct. It is evident that by this method, after the rubber tube has been passed, which is usually the case in a week or ten days, the new duct is lined with a mucosa and the reconstructed duct therefore as closely as possible resembles the normal structure.

[1] Surg., Gynec. and Obst., 1916, xx, 269.

SURGERY OF THE PANCREAS.

By JOHN B. DEAVER, M.D.,

AND

DAMON B. PFEIFFER, M.D.

ANATOMICAL CONSIDERATIONS.

The pancreas lies transversely across the posterior abdominal wall at the level of the bodies of the first and second lumbar vertebræ. In the midline it lies directly beneath an area 5 to 10 cm. above the normally placed umbilicus. The head is an expanded portion of the gland which is embraced by the concave loop of the duodenum, to which it is intimately adherent. A short narrow portion, known as the neck, immediately joins the head to the long tapering body and tail, the latter two divisions presenting no anatomical demarcation from each other.

During development in early embryonic life the pancreas is completely invested by peritoneum, but at a later period by the rotation of the gut and fusion of the peritoneum it comes to lie entirely behind the peritoneum. Here it is anchored by its vascular connections and surrounding areolar tissue to the posterior abdominal wall and neighboring structures. It is important to note that these connections permit a considerable degree of mobility which can be appreciated both with the hand in the abdomen and when conditions are such that the pancreas can be felt through the abdominal wall, provided that it is not the seat of an inflammatory or malignant process that causes it to be firmly adherent to its surroundings.

Posteriorly the pancreas crosses, from right to left, the vena cava, aorta, renal vessels, suprarenal gland and the upper pole of the left kidney. The tail is in close relation to the lower pole of the spleen and to the splenic flexure of the colon. The superior mesenteric vessels emerge beneath the neck of the pancreas in the angle formed by the neck and the lower prolongation of the head. The splenic artery and vein course above and behind its superior margin. These relations to the great abdominal vessels are responsible at times for severe, even fatal secondary hemorrhage, due to erosion by the combined infective and digestive action of the inflammatory process, in acute pancreatitis.

Anteriorly the pancreas is covered by the liver, the stomach, the gastrohepatic omentum, the gastrocolic omentum and the transverse colon. The relation which these structures hold to the pancreas is very variable. Körte,[1] in an examination of 30 cadavers, found that upon

[1] Deutsch. Chir., Lief. 45 D, 1898, Stuttgart.

opening the abdomen the pancreas was completely covered by the above structures in varying combinations. In ten cases some part of the gland was covered only by omentum, in six the head was exposed between the edge of the liver and the colon, in two it could be seen through the cleft between the right and left lobes of the liver, in three instances it lay behind the gastrohepatic omentum, and in one behind the gastrocolic omentum below the greater curvature of the stomach.

These relations possess great practical importance because of their bearing upon the presentation of cysts, tumors or inflammatory masses arising from the pancreas. They also make clear the possible routes of surgical approach to the organ. A pancreatic mass of sudden formation due to hemorrhage or inflammation carries before it the structures immediately superposed in approximately the same relations. In such acute swellings the stomach, as the most common overlying viscus, usually intervenes between the anterior abdominal wall and the pancreas. The smaller enlargements of a chronic nature naturally do not much disturb the relations of the covering structures. Larger masses, notably cysts, tend to push aside the stomach, liver, or colon and present beneath the abdominal wall covered only by the particular omental structure which happens to lie in the path of greatest enlargement. Thus, for example, a cyst may push forward above the stomach carrying before it the gastrohepatic omentum. It may pass below the stomach displacing this organ upward, the gastrocolic omentum being spread out upon the surface, or it may direct its way between the leaves of the transverse mesocolon, carrying the colon up against the abdominal wall or bulging through the lower layer of mesocolon into the general peritoneal cavity.

Similar anatomical considerations make it clear that the pancreas may be attacked surgically by the following routes:

I. Anteriorly:

(*a*) Through the gastrohepatic omentum.

(*b*) Through the gastrocolic omentum.

(*c*) Through the transverse mesocolon.

II. Posteriorly:

(*a*) By mobilizing the duodenum to reach the posterior surface of the head.

(*b*) Through the left loin and perinephric space to reach, retroperitoneally, the tail and body.

Exceptionally a cyst or inflammatory mass arising from the head of the pancreas may occupy the right subhepatic space.

Blood Supply.—The arteries supplying the pancreas are: (1) The superior pancreaticoduodenal, a branch of the gastroduodenal which runs downward over the head of the pancreas, sending numerous twigs to that portion of the gland and to the adjacent duodenum; (2) the inferior pancreaticoduodenal, derived from the superior mesenteric artery, running upward and to the right, supplying the posterior portion of the head and the neighboring duodenum; (3) an inferior pan-

creatic branch is given off usually by the superior mesenteric, which runs to the left, supplying the body along its lower border; (4) pancreatic branches of the splenic artery, varying in number are given off to the upper border of the body and tail; (5) pancreatic branches of small size are given off by the hepatic artery where it is in close relation to the head of the pancreas. Variations occur in the size and distribution of the above vessels. Opie[1] states that occlusion of the arteries supplying both pancreas and duodenum causes gangrene of the latter. Owing to its rich and varied arterial supply the pancreas is well protected against gangrene from stoppage of its circulation. The necroses which affect the organ do not depend simply upon circulatory disturbances.

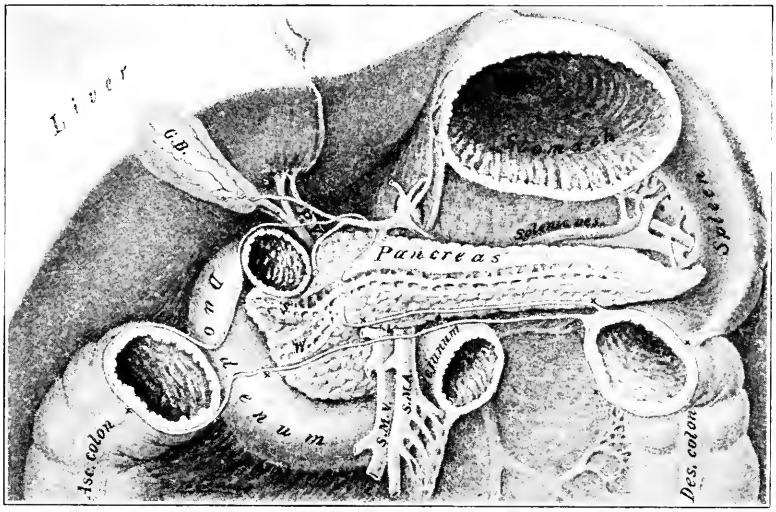


FIG. 225.—*x x x x*, reflection of peritoneum; *P.V.*, portal vein; *G.B.*, gall-bladder; *S.M.V.*, superior mesenteric vein; *S.M.A.*, superior mesenteric artery; *S*, duct of Santorini; *W.*, duct of Wirsung.

The veins of the pancreas empty into the portal vein either directly or through the medium of the superior mesenteric or splenic veins.

The Lymphatics.—Too little attention has been paid to the lymphatics of the pancreas and to the part which they play in the pathogenesis of pancreatic inflammation.[2] Around each lobule of the pancreas there is a network of lymph vessels. These unite to form larger channels which run in the interlobular framework of connective tissue in company with the bloodvessels and the collecting ducts. The pancreas has no single hilum and as is the case with the bloodvessels, the lymphatics emerge from the pancreas at various points along its entire surface. From this arrangement it is seen that the lymphatic drainage of one section of the pancreas has but little relation to that of other

[1] Diseases of the Pancreas, 1910, p. 22.

[2] For detailed information of the anatomy of the vessels the work of Bartels should be consulted. Arch. f. Anat. u. Physiol., Anat. Abt., 1904, p. 299; 1906, 250; 1907, 267.

portions, though anastomoses exist between adjacent systems of vessels. The lymphatics of the duodenum possess free and intimate anastomoses with the lymphatics of the head of the pancreas. Similarly Franke[1] has shown that the lymphatics of the gall-bladder and bile ducts which pass downward in the right free border of the gastrohepatic omentum on their way to the thoracic duct course over the posterior surface of the head of the pancreas, likewise anastomosing freely with the lymphatics emerging from the pancreas. He has even succeeded in injecting the lymphatics of the upper portion of the head of the pancreas from the gall-bladder. These are important considerations in the elucidation of the pathogenesis and localization of pancreatic infections.

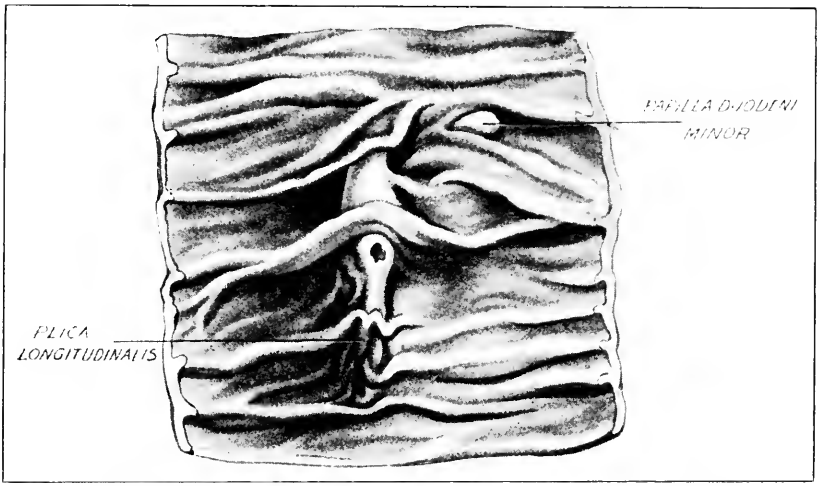


FIG. 226.—Longitudinal fold with papilla and accessory pancreatic duct.

The Pancreatic Ducts.—The pancreas develops from two buds given off by the primitive gut, one dorsal and one ventral (some authorities speak of two ventral buds). These buds by progressive division form the duct systems of the gland, and about their terminals form the mantles of parenchyma cells which are its secreting elements and are grouped in lobules. During the process of development the two separate *anlagen* fuse to form a single gland but the method of development is still evidenced in the adult in the existence of two separate ducts. The greater portion of the gland is derived from the dorsal *anlage* but, strangely, the secretory duct, which represents the persistence of the outgrowth from which this larger part of the pancreas develops, now becomes the smaller and less important duct of excretion, namely, the duct of Santorini, while the duct of the ventral bud after fusion with the dorsal rudiment outstrips its fellow and becomes the larger duct of Wirsung, which in almost all instances is the principal channel of discharge of the pancreatic secretion.

[1] Deutsch. Ztschr. f. Chir., 1911, cxi, 539.

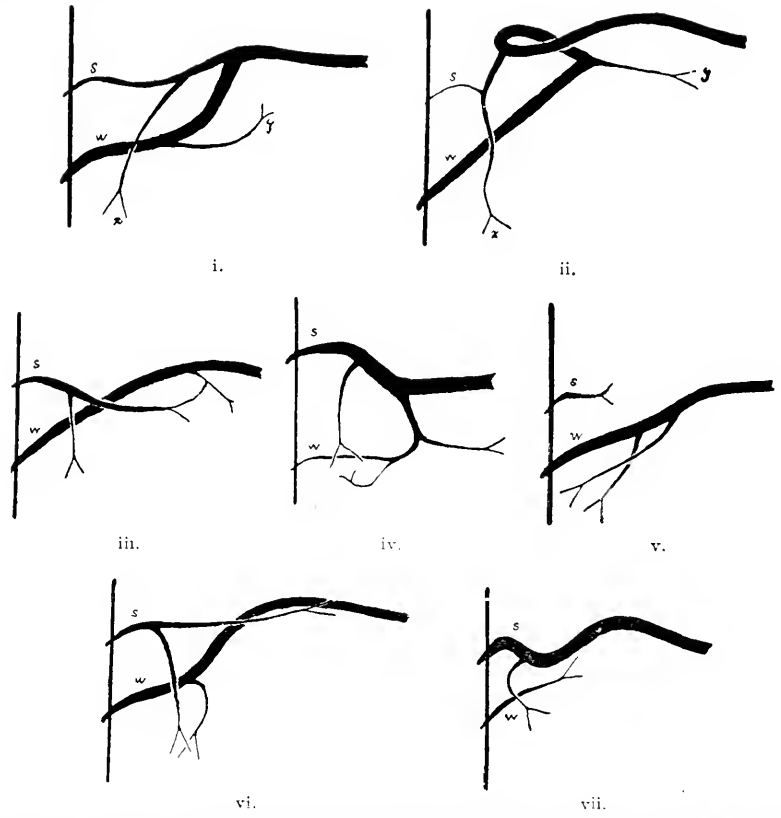


Fig. 227.—Varying relations of the duct of Santorini (*S*) to the duct of Wirsung (*W*). Drawn from dissected specimens. (Opie.)

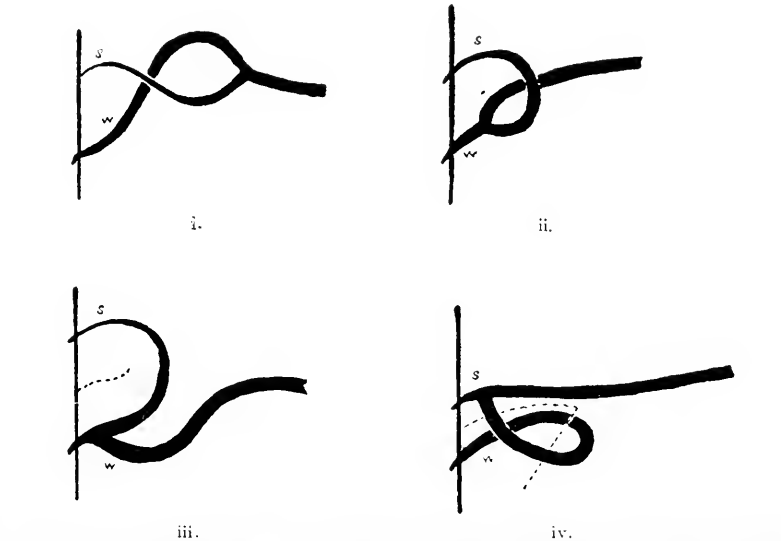


Fig. 228.—Varying relations of the duct of Santorini (*S*) to the duct of Wirsung (*W*). Broken lines are in the plane of the interlobular fissure. Drawn from dissected specimens. (Opie.)

Many variations exist in the relative size, patency and freedom of anastomosis between the two ducts, details of which may be found in the work of Schirmer[1] and Opie.[2]

Summarized, Schirmer found the following variations in the ducts:

Ducts in anastomosis and patent:
Duct of Wirsung larger, 60.
Duct of Santorini larger, 6.
Ducts in anastomosis, one wholly or partially obliterated:
Papilla of duct of Santorini not patent, 24.
Duct of Wirsung absent, 5.
Ducts not in anastomosis:
Duct of Wirsung larger, 5.
Duct of Santorini larger, 4.

Opie in 100 cases described variations as follows:

I. Ducts in anastomosis:
1. Duct of Wirsung larger.
(*a*) Duct of Santorini patent, 63.
(*b*) Duct of Santorini not patent, 21.
2. Duct of Santorini larger or equal in size to duct of Wirsung.
(*a*) Duct of Wirsung patent, 6.
(*b*) Duct of Wirsung not patent, 0.

II. Ducts not in anastomosis:
1. Duct of Wirsung larger, 5.
2. Duct of Santorini larger, 5.

These variations undoubtedly are of pathological and clinical significance but, naturally, cannot be determined during life.

The Relation of the Common Bile Duct to the Head of the Pancreas and the Duct of Wirsung.— In approximately two-thirds of all cases (62.5 per cent.[3]) the common duct is completely surrounded for a varying distance by pancreatic tissue. In the remaining one-third (37.5 per cent.) it occupies a groove upon the surface of the head of the pancreas. This arrangement not only makes possible obstruction of the common duct by tumefaction of the embracing ring of pancreatic tissue, but also exposes the adjacent pancreas to disease communicated from the common duct by contiguity or by lymphatic transmission. What Mayo has aptly termed "the association of terminal facilities" of the common bile duct and the duct of Wirsung is also fraught with significance. Typically the common bile duct and the duct of Wirsung pass side by side obliquely through the coats of the duodenum within which they unite to form a common channel, the diverticulum or ampulla of Vater, which opens into the intestine through a small conical projection or papilla. Obstruction to this outlet will exert its effect not only upon one of the ducts but to a greater or less degree upon the other. The two duct systems may be thrown into direct communication through the medium of the common chamber into which they empty,

[1] Arch. f. mikr. Anat., 1898, lii, 773.
[2] Diseases of the Pancreas, Philadelphia, 1910, p. 7.
[3] Helly: Arch. f. mikr. Anat., 1900, lvi, 291.

with the result that the secretions from the gland of higher secretory pressure, the liver, may be forced backward into the ducts of the pancreas with results well illustrated by the classical case of hemorrhagic pancreatitis observed by Opie, due to stone in the papilla of Vater, an observation which was the incentive to much interesting experimentation that has enriched our knowledge of the pathogenesis of pancreatic disease.

Less commonly the pancreatic duct may empty into the common duct without the formation of an ampullary dilatation, or the two ducts may open side by side, but separately, into the duodenum.

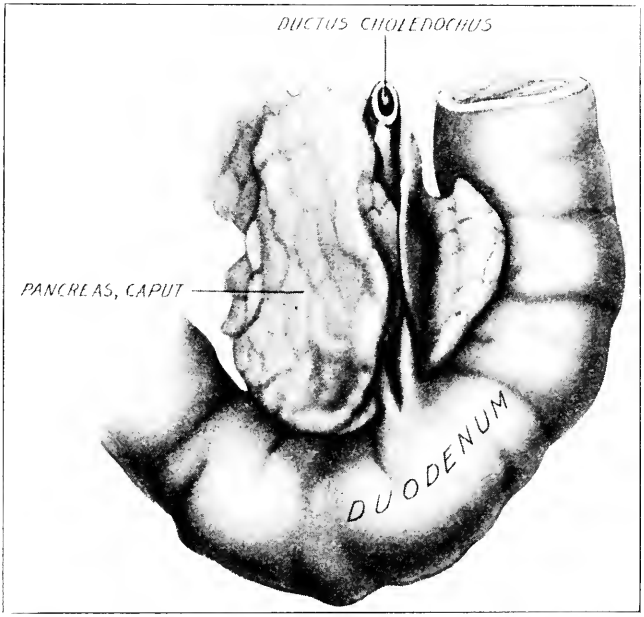


FIG. 229.—Common and pancreatic duct in groove of pancreas.

PHYSIOLOGY OF THE PANCREAS.

The pancreas is the most important gland of digestion. It secretes daily about 1500 c.c. of pancreatic juice. The secretion contains the ferments or proferments which when activated are capable of breaking down the proteids, fats and starches of the food into less complex substances which can either be absorbed directly or further digested by the succus entericus. These ferments are known respectively as trypsin, lipase or steapsin, and diastase or amylopsin. Less important than these are small amounts of a rennet-like ferment, also maltase, which can convert maltose into glucose and nuclease which dissolves the nucleins. The presence of these powerful ferments in the gland gives rise to certain important and peculiar effects in disease of the pancreas, the best known of which are fat necrosis and hemorrhagic necrosis.

In addition to its external secretion the pancreas supplies an internal secretion which is essential to carbohydrate metabolism. There is evidence also of the presence of a second internal secretion which is necessary in order that the intestine may properly exercise its function of absorption.

Pathological Physiology. In the case of an organ with such extraordinarily varied and important functions it is natural to inquire whether its varied disorders are reflected in disturbances of function, whether these functional disturbances are distinctive in kind and proportionate in degree to the underlying disease and *per contra*, whether demonstrable abnormalities of function may be of practical service in diagnosis. The two striking phenomena just mentioned, fat necrosis and pancreatic hemorrhage, are examples *par excellence* of such effects but are unavailable for diagnosis except in the serious types of the disease and only during operation.

The tests designed to demonstrate the functional activity of the pancreas fall naturally into three groups:

1. Tests of external secretion in,
   - (*a*) Duodenal contents.
   - (*b*) Gastric contents.
   - (*c*) Stool.
   - (*d*) Urine.
   - (*e*) Blood.
   - (*f*) Action upon test materials introduced into the alimentary tract.
2. Tests of internal secretion in,
   - (*a*) Urine.
   - (*b*) Stool.
   - (*c*) Effects exercised through medium of sympathetic nervous system.
3. Metabolic studies on absorption of fat, nitrogen, etc., from intestines.

Attention was called early to the abnormal character of the stools in certain cases of advanced pancreatic disease. Bright,[1] in 1833, clearly described the excessive amount of fat occasionally found in the stools in this condition (steatorrhea). At the same time he recognized the inconstancy and unreliability of the symptom as indicative of pathological changes in the gland. The "frequent, bulky motions, pale in color, offensive and obviously greasy," as described by Robson, are strongly suggestive of deficiency or absence of the external secretion of the pancreas with consequent failure of digestion. The abundance of fat and fatty acids is due to a deficiency of lipase, and the lack of tryptic activity is shown by the presence of striated muscle fibers in a more or less incomplete state of digestion (creatorrhea).

The attempt has been made to increase the value of such derangements by more accurate metabolic studies. The intake and output

[1] Med.-Chir. Tr., 1833, xviii, 1.

of fat and nitrogenous material are easily capable of estimation, and it may be roughly stated that the more serious and advanced the disease of the pancreas the greater the loss of fat and nitrogen. Unfortunately for the practical utility of such estimation it has been found that the factors involved are of such complexity and their interrelationship so uncertain that clinical deductions are untrustworthy. The body possesses certain "factors of safety" which may prove sufficient to carry on digestion in the complete absence of the external secretion of the pancreas. Moreover, absorption may be greatly impaired from other causes even when the pancreatic ferments are abundantly secreted and fully capable of playing their full part in digestion. Evidence exists to show that the pancreas itself normally possesses an internal secretion or "hormone" which is essential to proper absorption of the food from the intestine and that this may be deficient even though the external secretion be normal. Other disease, such as abdominal tuberculosis, may interfere with intestinal absorption. Crohn,[1] from a résumé of the literature and his own metabolic studies, concludes that: 1. The nature of the disease (of the pancreas) does not determine the degree of fat and nitrogen loss.

2. The amount of food absorption is independent of the patency of the duct or the activity of the enzymes of the external secretion of the gland.

3. The degree of interference with intestinal absorption is dependent on organic disease or functional derangement of the parenchyma of the gland, the pancreas probably normally controlling intestinal absorption by an internal secretion or hormone.

The classical experiments of von Mering and Minkowski[2] proved that an internal secretion of the pancreas was essential to carbohydrate metabolism. Complete pancreatectomy is invariably followed by a rapid and fatal diabetes. Pancreatic disease in certain cases placed, by Fitz[3] at 38 per cent. and by Deaver[4] in an operative series comprising earlier cases, at 5.3 per cent., is associated with glycosuria. There is no reason to doubt that glycosuria in these conditions is dependent upon a diminution or perversion of the internal secretion of the pancreas. It may be intermittent and called forth by exacerbations of the pancreatic disease. More recent studies, notably those of Opie, have indicated that the islands of Langerhans are the anatomical elements of the pancreas chiefly, if not solely, concerned with this particular secretion. It is not possible in all cases of diabetes to demonstrate disease of the islands, nor is it believed that all glycosuria is of pancreatic origin. The islands may undergo extensive degeneration without evidence of disease of the secretory parenchyma and conversely the acini may show marked pathological changes without apparent change in the islands or disturbance of their function. It may be said,

[1] Arch. Int. Med., 1915, xv, 602.
[2] Arch. f. exper. Path. u. Pharm., 1899, xxvi, 371.
[3] Tr. Congr. Am. Phys. and Surg., 1903, vi, 36.
[4] Jour. Am. Med. Assn., 1911, lvi, 1079.

however, that glycosuria when associated with other evidence of disease of the pancreas tends to substantiate the diagnosis.

The Cammidge reaction in the hands of its originator is credited with a high degree of accuracy in the diagnosis of pancreatitis. But in over 1000 cases of upper abdominal disease in the Lankenau (formerly the German) Hospital of Philadelphia we have not found it helpful. Some favorable opinions are to be found in the literature, notably Robson and Moynihan, with the former of whom Cammidge has been associated, but the weight of experience in other clinics has been against the reliability of its results.

Loewi's[1] pupillary reaction is founded on the fact that in pancreatectomized animals, dilatation of the pupil is caused by the instillation of adrenalin into the eye, which under normal conditions produces myosis. He attributes the reaction to an increased irritability of the central nervous system. A number of authors have observed this phenomenon in man, though inconstantly and in a varying percentage of cases. Other similar effects of sympathicotonia, such as the ocular phenomenon more commonly associated with hyperthyroidism, and tremor, as well as Kocher's sign of tenderness of the thyroid have been found associated with pancreatic disease but only as inconstant, inconspicuous and relatively valueless signs.

The presence and the activity of the external secretion of the pancreas may be tested for indirectly by introducing into the alimentary tract certain substances which undergo recognizable changes when acted upon by the pancreatic ferments or, directly, by estimating the ferment activity of the duodenal contents obtained *in situ* or after regurgitation into the stomach, or of the ferments in the stool, urine or blood.

Examples of the indirect method are Sahli's glutoid capsules and the sic gelodurat capsule of Müller and Schlecht which are unaffected by the gastric juice but are dissolved by active pancreatic secretion in the intestine, liberating substances chemically recognizable when absorbed and excreted in the urine, or observed free in the stool after dissolution of the capsule. Schmidt's nuclein test consists in the administration of thymus or other tissues rich in nuclei, which are later searched for in the feces, incomplete digestion indicating a deficiency of the nuclease of the pancreas. Atchley[2] found Schmidt's test negative in a case of complete occlusion of the pancreatic duct and concluded that in the human subject the digestion of nuclear material, the purin metabolism and the uric acid formation do not depend on the presence of the pancreatic secretion in the intestinal canal. In Ehrmann's palmitin test the digestion of this fat can be determined by a chemical color reaction of the liberated fatty acid with copper acetate. Still other tests based on similar principles have been proposed. But all these tests have been shown to be subject to disturbing factors that cannot be eliminated and which greatly reduce their value.

[1] Arch. f. exper. Path. u. Pharm., 1909, lix, 83.
[2] Arch. Int. Med., 1915, xv, 654.

Under normal circumstances trypsin, steapsin and diastase can be demonstrated in the feces and their activity determined quantitatively. While an approximate normal can be determined the attempt to correlate departures from that normal to disease of the pancreas has been in the main unsatisfactory.

Boldyreff[1] discovered that duodenal contents could be caused to regurgitate into the stomach by ingestion of a large amount of olive oil. Volhard[2] has applied this method of obtaining pancreatic juice in the clinic. More accurate and ingenious is the method introduced by Einhorn for the recovery of duodenal contents, which as now modified consists in the introduction into the stomach of a rubber tube of fine bore with a perforated metal olive-shaped tip. The tube is of sufficient length to reach the duodenum, into which, in a few hours, the metal tip usually finds its way. Duodenal juice may then be aspirated and tested directly for ferments. More constant results have been claimed for the results of examinations thus made.

The findings with this method during the last five years, however, show conclusively that the problem of correlating functional abnormalities with the underlying pathology of the pancreas remains yet to be solved so far as results of practical utility are concerned.

Wohlgemuth[3] found that in experimental occlusion of the pancreatic duct the amount of diastase in the urine rose greatly. He observed the same phenomena in acute pancreatitis and functional disturbance of the pancreas. Wohlgemuth and Noguchi[4] attach great importance to a marked rise in the diastase of the blood and urine as indicative of injury to the pancreas in cases of abdominal traumatism.

ABNORMALITIES OF THE PANCREAS.

Abnormalities of the pancreas are not uncommon. Minor alterations in size and shape are the rule. One or more deep constrictions may be found. The tail is sometimes forked. Fusion of the two *anlagen* may fail to occur with the result that two separate glands are found.

Accessory Pancreas.—Aberrant islands of pancreatic tissue have been found many times and are probably more common than is suspected. As a rule they are in the wall of the stomach or duodenum, but they have been observed in various portions of the intestinal tract as far down as the lower ileum. They always have a duct connecting them with the bowel.[5] A number of cases of gastric or intestinal diverticula associated with aberrant pancreatic tissue have been described. Such diverticula may be the seat of acute inflammation and have been known to cause intestinal obstruction.

Annular Pancreas.—A curious though uncommon anomaly which may possess surgical significance through the possibilities of obstruc-

[1] Zentralbl. f. Physiol., 1904, xviii, 457.
[2] München. med. Wchnschr., 1907, liv, 403.
[3] Biochem. Ztschr., 1908, ix, 1.
[4] Berl. klin. Wchnschr., 1912, i, 1069.
[5] Zenker: Virchows Arch., 1861, xxi, 369.

tion of the duodenum is that in which the head of the pancreas entirely surrounds the duodenum.

The Islands of Langerhans.— Centrally situated within the lobules of the pancreas are small globular or ovoid collections of cells which appear quite distinct from the surrounding parenchyma. They have an origin[1] in common with the secreting acini but they are not arranged in tubules. They are not encapsulated or entirely independent from the

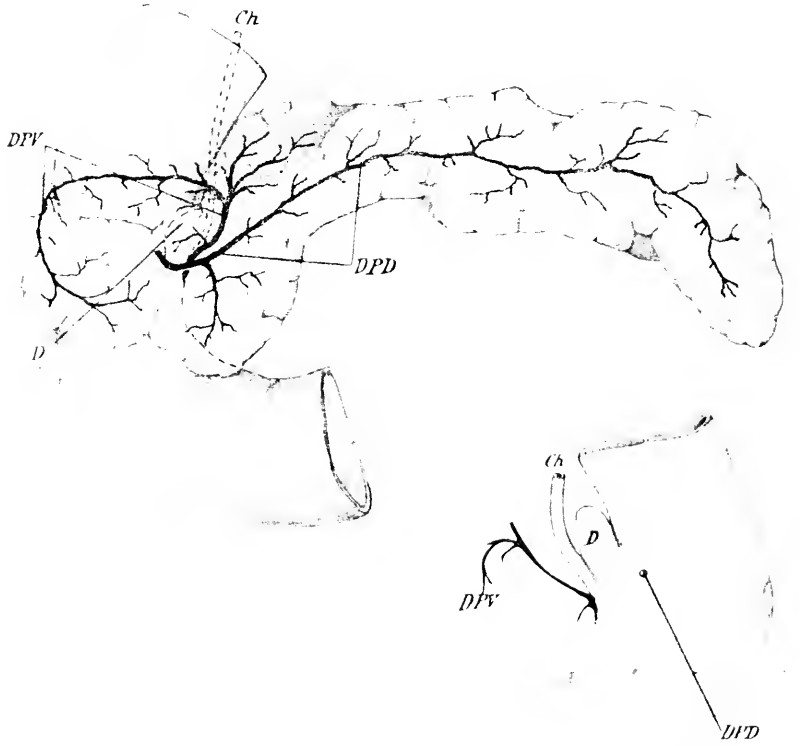


FIG. 230. Annular pancreas. Cords. Anat. Anzeiger. 1911, xxxix, p. 33. *Ch*, choledochus; *DPD*, duct of dorsal pancreas; *DPV*, duct of ventral pancreas; *D*, diverticulum of duodenum.

parenchyma of the acini as direct connections can be traced between the two different types of epithelium by means of slender cords or tubules.[2] There is strong evidence to support the idea that they are the source of an internal secretion essential to the proper metabolism of carbohydrates in the body.

[1] Pearce: Am. Jour. Anat., 1903, xi, 445.
[2] Opie, Pearce, Karakascheff, Cecil.

INJURIES OF THE PANCREAS.

Wounds.—Wounds of the pancreas occur in three forms: (1) Penetrating wounds, (2) gunshot wounds, and (3) subcutaneous rupture.

Penetrating Wounds.—Penetrating wounds most often result from a stab. Gunshot wounds are common in war and are almost uniformly fatal under the conditions of military surgery.[1] In civil life they are less common than subcutaneous rupture or laceration of the organ which is due to the application of blunt force to the abdominal wall over the pancreas crushing the organ between the object inflicting the violence in front and the vertebral column behind. The relative frequency of these types of injury is indicated by Mikulicz's[2] statistics. He found in 45 cases of injury to the pancreas 24 subcutaneous ruptures, 12 gunshot wounds and 9 stab wounds.

In all types of pancreatic injury there are usually more or less serious wounds of other viscera. Instances of isolated injury of the pancreas have been reported in all the above types, but, as a rule, the associated lesions are severe and often attract the most immediate attention. So true is this that all who have been interested in the subject have emphasized the necessity of considering carefully the condition of the pancreas in all cases where it has been exposed to the possibility of injury in order to avoid overlooking a lesion.

Gunshot Wounds.—Luxembourg[3] collected 31 cases of gunshot wound of the pancreas. Of the 24 operated upon 13 died and 11 recovered; 7 not operated upon died. Famous and sad cases of fatal gunshot wounds of the pancreas are those of Presidents Garfield and McKinley.

Holzwarth[4] reports the case of a soldier who was shot through the pancreas, who made an immediate recovery but later was operated upon for pancreatic cyst which followed the track of the bullet and required incision both anteriorly and posteriorly. In Luxembourg's series the pancreas alone was injured only three times with two recoveries and one death. Other organs injured were, liver 12, stomach 14, intestines 3, left kidney 2, heart 1, rib 1, vertebral column 1, scapula 1.

Treatment.—There are no immediate symptoms by which the participation of the pancreas in gunshot or stab wounds may be known. As

[1] Observations made during the late war substantiate this statement. Thus Wallace (War Surgery of the Abdomen, J. and A. Churchill, London, 1918, p. 105) states that "in 965 operated cases the pancreas was wounded 5 times. Very few of such injuries have been noted. Probably many are missed and diagnosed as retroperitoneal hematoma. In addition, many may be rapidly fatal; the association of the gland with big vessels needs hardly be mentioned . . . the wound was associated three times with other viscera; stomach; stomach and liver; stomach and kidney—all fatal; alone on two occasions. One went to base without symptoms, the other died. There are no distinctive symptoms; the lesions are found at exploration and are sometimes accompanied by fat necrosis." Makins (Brit. Jour. Surg., March, 1916, p. 655) says that "injuries to the pancreas are difficult to detect except by direct exposure of the organ . . . the typical results of the escape of the pancreatic secretion into the tissues and peritoneal cavity have been observed. Such injuries have usually proved fatal."

[2] Mitt. a. d. Grenzgb. d. Chir u. Med., 1903, xii, 1.

[3] Deutsch. Ztschr. f. Chir., 1912, cxvii, 284.

[4] Pester med-chir. Presse, 1915, xxi–xxii, 64.

all such injuries are to be treated by immediate laparotomy it remains only for the surgeon to bear in mind the possibility and to explore for evidences of injury to the pancreas. If in doubt the posterior peritoneum should be opened and areas suffused with blood, carefully searched. Failure to detect and properly drain pancreatic wounds is apt to result fatally. Moynihan recommends posterior drainage. While this is probably preferable in wounds of the tail or body, wounds of the head, can be better drained anteriorly.

Subcutaneous Rupture.— Subcutaneous rupture occurs most often from the kick of a horse, the passing of a wheel over the body, a blow in the epigastrium by a wagon tongue or shaft or by being squeezed between two cars.

Symptoms.—Extreme pain and collapse commonly follow subcutaneous rupture. Vomiting is usually present. Early, the temperature and pulse are subnormal as in shock; later they tend to rise. The epigastrium is tender and the muscles moderately rigid. Free fluid in the abdomen may be demonstrable and after a time, in some cases, dulness in the left hypochondrium and loin indicate the presence of blood or an effusion in the lesser peritoneal cavity.

Wohlgemuth and Noguchi[1] have demonstrated an increase of diastase in the blood and urine after pancreatic injury and maintain that in all cases where this increase is markedly above the normal, following a blow upon the abdomen, one can be sure that the pancreas is injured.

Subsequent symptoms depend much upon the turn taken by the lesion. Hemorrhage from the pancreas itself is rarely so severe as to be alarming. The injury may, however, cause hemorrhage into the pancreas itself and extravasation of pancreatic secretion can set up all the symptoms of *pancreasvergiftung* as seen in acute hemorrhagic pancreatitis.

Localized abscess, peritonitis or retroperitoneal suppuration may occur. In some instances a sterile pseudocyst forms and is discovered as a mass several weeks or months after the injury.

Prognosis.— Heinecke[2] collected 19 cases of rupture of the pancreas of which five died without operation. Of the 14 cases operated upon nine recovered. No case died in which the lesion received timely recognition and treatment. Guleke[3] likewise recommends immediate operation but states that when the symptoms are evidently subsiding it is better to wait until adhesions have formed about the extravasate.

Treatment.— The arguments in favor of immediate operation are unanswerable, as only in this way can the dangers of pancreatic intoxication, necrosis and infection be anticipated. Doubtless in cases that eventuate in sterile pseudocysts the necessity is less pressing, but there is no way of forecasting such an outcome in the individual case. At operation blood or serosanguineous fluid in moderate amount is usually found free in the abdominal cavity. The mesentery and omenta may

[1] Berl. klin. Wchnschr., 1912, xlix, 1069.
[2] Arch. f. klin. Chir., 1907, lxxxiv, 4.
[3] München. med. Wchnschr., 1910, v, 75.

be infiltrated with blood, and behind the peritoneum, the pancreas and peripancreatic tissues may be the seat of a large boggy infiltration of blood and pancreatic secretion. At other times, the amount of bleeding and local signs of pancreatic injury may be so slight as to make detection difficult. Often when operation has been deferred twenty-four hours or more, in the neighborhood of the pancreas are seen flecks of fat necrosis which are more numerous and larger in its more immediate vicinity.

The procedure to be adopted in these cases will vary in accordance with the location, degree and character of the lesion. The head and body are the portions which are most often injured. The rent may be clean and sharp as if made with a knife, or it may be ragged and the adjacent tissues pulpified. A number of instances of complete transverse rupture are on record. One such case was reported by Garré[1] which recovered after the two portions were united by suture. Garré collected nine other cases of complete transverse rupture, all of which were fatal.

Resection, drainage and suture are the methods of treatment available. The first is no longer to be considered. The difficulties add to the danger of the operation and it is known that it is unnecessary to remove a part of the pancreas even if totally disconnected from the remainder.

What can be accomplished by suture is at present not entirely settled. It is futile to attempt to repair severed ducts. Yet we cannot say that ducts will not find their way across a clean line of union after healing by first intention. When the gland is not completely severed it is likely that the ducts in the uninjured portion enlarge to convey the secretion from the partially isolated gland distal to the rupture. Suture is subject to the disadvantage, which has been observed, of causing an inflammatory reaction and fat necrosis in the tract of the sutures. If used, the sutures should be gently placed, of fine material, and should include in their grasp as little pancreatic tissue as possible. However, it should be said that drainage of the sutured area minimizes the danger of extension of inflammation due to manipulations and suture necrosis.

In a large proportion of cases it is evident that repair by suture is out of the question. Reliance must then be placed entirely on drainage which is so arranged and fixed in position that it will carry off all blood and pancreatic secretion from the injured area. Drainage is by far the most important consideration in the treatment of these cases. Repair is probably of little importance so far as the pancreas is concerned even where it can be effected. As a means of restoring anatomical relations and obliterating what would otherwise be a dead space it may be more useful.

Fistula which may be very persistent and annoying is a common sequel. In the event of complete severance of a portion of the gland the fistula will discharge until atrophy of the secreting acini occurs.

[1] Beitr. z. klin. Chir., 1905, xlvi, 1.

In other cases the discharge lasts until there is marked cicatrization of the injured surface and formation of sufficient collateral ducts. In chronic cases the Wohlgemuth diet should be tried. Heinecke[1] reports a case which had persisted eighty days, but closed in three days after the adoption of an antidiabetic diet. König[2] also had a strikingly favorable example of the efficiency of this diet. As fistula formation and persistence does not in every case depend upon the amount and irritating character of the secretion, the diet will not prove efficacious in every instance. Körte ingeniously and successfully dissected out a chronic fibrous sinus and joined it to the bowel (fistulo-anastomosis).

In all cases the skin should be protected at once from the action of the discharge by vaselin or a bland ointment. Kroiss[3] reports a successful case of subcutaneous rupture of both duodenum and pancreas in which difficulty was experienced during convalescence owing to the external discharge of practically all the pancreatic secretion and consequent defective digestion and nourishment. He observed excellent results from the use of crepton, and others have recommended predigested foods in similar conditions.

INFLAMMATION OF THE PANCREAS.

Pathogenesis of Pancreatic Inflammation.—The retroperitoneal position of the pancreas, the difficulty of gaining by inspection or palpation an exact idea of the condition of the organ during life even when the abdomen is opened, the complexity of the factors introduced by its numerous and extraordinary functions, as well as the indifference and neglect with which it has been treated until very recent times, have left many gaps to be filled before a complete understanding of its diseases can be said to have been reached. However, by a combination of recent clinical and pathological observations with data supplied by experiment we are in a position to draw a number of very important conclusions.

A difficult question has been the role of infection in pancreatitis. It must be admitted that under certain conditions the pancreas has the property of destroying itself by means of its own ferments. The earliest observations were made upon cases in which the ferment phenomena were the striking features. Fat necrosis and hemorrhage showed no obvious relation to infection. Such infections as were found could readily be explained as secondary invasion of injured tissues. The classical case reported by Opie, of a gall-stone impacted in the papilla of Vater in a case of hemorrhagic pancreatitis led to the discovery that the disease could be reproduced by injection of bile and other sterile materials into the pancreatic duct. Since Opie's case a number of similar occurrences have been noted and in the ideas of pancreatitis suggested by this mode of causation and by the type of experiments to

[1] Zentralbl. f. Chir., 1907, xxxiv, 265.
[2] München. med. Wchnschr., 1907.
[3] Beitr. z. klin. Chir., 1911, lxxvi, 477.

which it gave the incentive, the factor of infection was either disregarded or assigned a very subsidiary role. Cases of traumatic pancreatitis also emphasized the fact that infection was not a necessary agent in the production of the essential features of acute pancreatitis. Gradually, however, it became clear that at least some of the cases of acute pancreatitis were to be accounted for in some other way than by the impaction of a gall-stone in such a manner as to cause retrojection of bile into the pancreatic duct, since in a percentage of cases gallstones were absent. Bobitzki[1] reported a case of fatal acute pancreatitis associated with cholelithiasis. The ducts were dissected out and found to enter the duodenum side by side, no ampulla being present. Two-thirds of the gland were destroyed. Bacteria could not be demonstrated. Carwardine and Short[2] describe a case of acute pancreatitis affecting an accessory pancreas in the wall of the jejunum one and one-half inches beyond the duodenojejunal junction. Simple obstruction of the duct was shown to produce atrophy without the characteristic inflammatory changes. The hypothesis of regurgitation of duodenal contents into the duct received considerable attention. Hlava[3] found that duodenal contents injected into the duct produced acute hemorrhagic pancreatitis. Seidel[4] showed that occasionally it is possible for duodenal contents to enter the duct of Wirsung. Other observers have been unable to obtain this result and maintain that the obliquity of that portion of the duct which penetrates the duodenum is sufficient defense against reflux of the duodenal contents. Körte,[5] Oser[6] and others attempted to reproduce the disease by various methods of altering and disturbing the blood supply but nothing comparable to the clinical condition resulted. The net results of the vast amount of experimental work along these and similar lines established the fact that pancreatitis could be produced by the injection of various substances into the pancreatic duct, the only feature which these methods possess in common being found in injury of the tissues and activation of the pancreatic juice within the substance of the gland. The only demonstrated clinical parallel remained in the circumstances illustrated by Opie's case of stone impacted in the common ampulla of the bile and pancreatic ducts.[7] To account for the residue of cases in which this mechanism was ruled out, more recent work has reverted to the role of infective processes which play the chief part in the inflammation of all other glands which by their position are exposed to the chance of infection. Another circumstance which directed attention to infection

[1] Arch. f. klin. Chir., 1912, xcvii, 143.
[2] Ann. Surg., 1913, i, 653.
[3] Bull. internat. de l'acad. des sciénce de Bohème, 1897.
[4] Beitr. z. klin. Chir., 1913, lxxxv, 350.
[5] Berl. Klin., December, 1896.
[6] Nothnagel's spec. Path. u. Ther., p. 338.
[7] Archibald, of Montreal, believes that the forcible injection of bile into the pancreatic duct may occur as a result of excessive toxicity or spasm of the sphincter of Oddi, which controls the outlet of the papilla of Vater. He has shown that this sphincter may resist a pressure of 300 to 700 mm. of water and that in cats it was possible to inject the pancreatic duct from the choledochus by suddenly raising the pressure in the bile duct or by throwing the spincter into spasm by the application of acid.

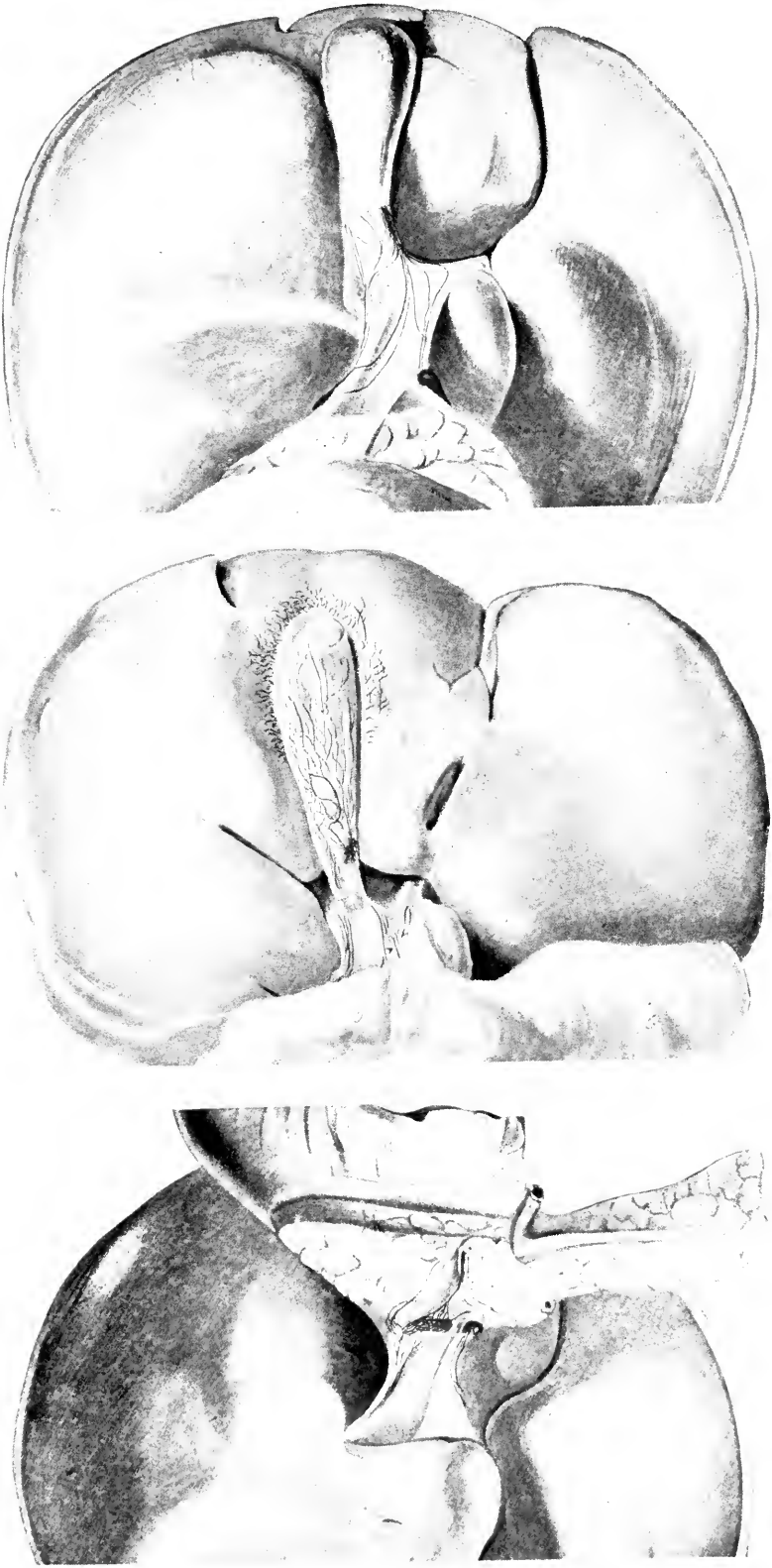
of the pancreas was the observation that chronic and subacute pancreatitis, as frequently observed at operation, is associated in the vast majority of cases with frankly infective processes of the biliary tract and to a less extent with pyloric or duodenal ulcer and with such other lesions of the gastro-intestinal tract as give rise to retroperitoneal inflammation. The conditions found in the pancreas could be explained on no other basis than that of bacterial activity. Still the idea of duct-borne agencies ruled medical thought and it was assumed that infection extended by way of the ducts. In those cases of pancreatitis associated with disease of the biliary tract it was easy to picture a catarrhal infection propagated directly from the bile duct up the pancreatic duct which is in such close relation to it. While this did not explain pancreatitis associated with other lesions, it was still possible to assume direct infection of the duct from the duodenum. Deaver and Pfeiffer[1] have pointed out several factors which strongly militate against this facile explanation. In their experience about one-third (36 per cent.) of all instances of chronic pancreatitis, and 12 per cent. of acute cases were not accompanied by demonstrable disease of the biliary passages. This is evidence that in a large proportion of cases the inflammatory process is not communicated to the pancreas from an infected bile duct. Moreover, there is a lack of parallelism between pancreatic and biliary disease in their sex incidence. It is well known that gall-bladder disease is more frequent among women, the ratio being about three to two. In pancreatitis the ratio is reversed. This corresponds with the original observations of Fitz and with subsequent experience of surgeons the world over who agree that pancreatitis is more common in the male sex. Evidently pancreatitis is something other than a disease dependent upon primary inflammation or lithiasis of the biliary tract.

Furthermore, in the early cases, which are evidently secondary to cholecystitis, it is generally agreed that it is the head and often only the upper portion of the head of the pancreas that is chiefly affected, the remainder of the gland frequently being normal, so far as can be determined by inspection and touch. Now this portion of the gland is not in the closest relation to the duct of Wirsung, and, in any event, it is difficult to understand why an infection arriving by way of the duct should not involve symmetrically the entire gland rather than merely a portion of the head.

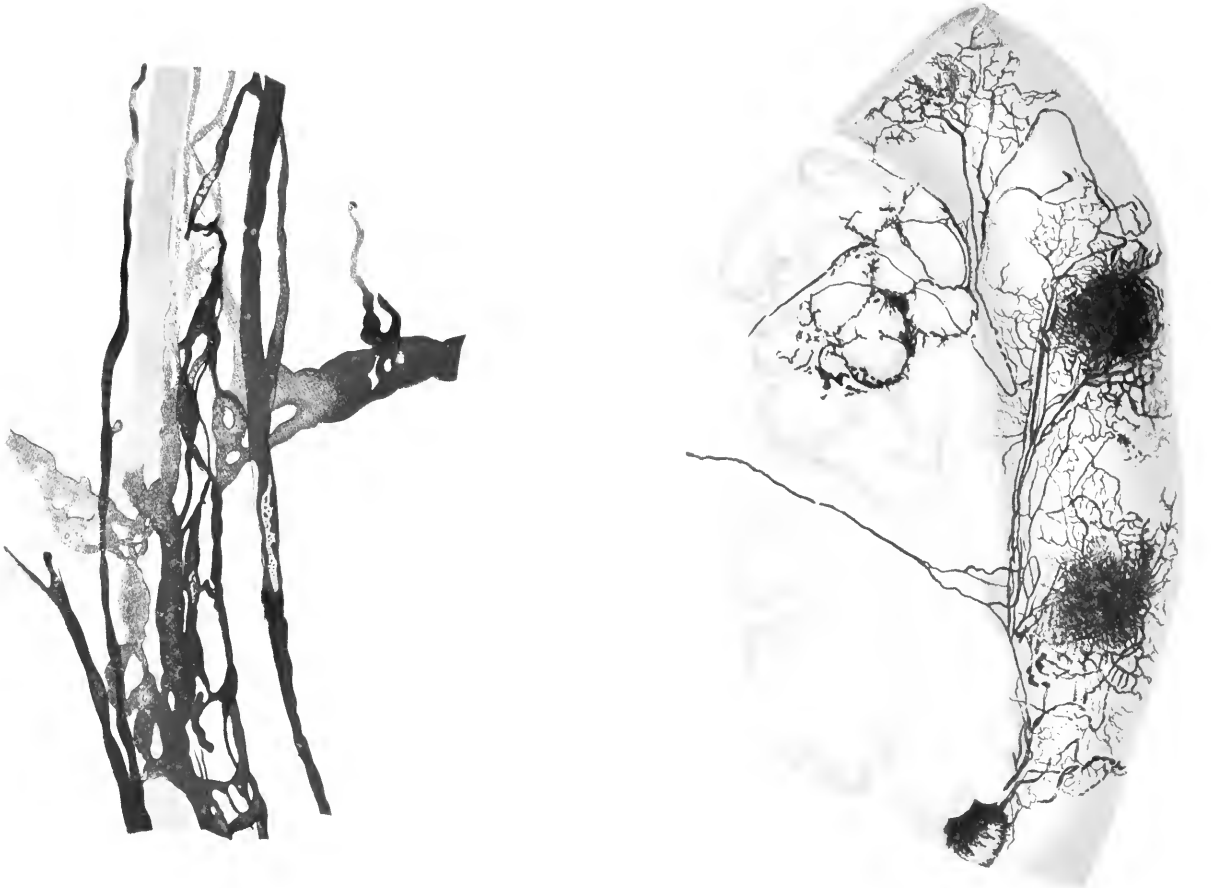
On the other hand, if we ascribe the infection of the pancreas to those great carriers of bacteria and infective products, the lymphatics, these peculiarities are readily explained. Bartels showed that an extraordinarily intimate relation exists between the lymphatics of the duodenum and other abdominal organs and those of the head of the pancreas.

Franke[2] made a special study of the lymphatics of the gall-bladder and was able to show a similar close connection to those of the pan-

[1] Am. Jour. Med. Sc., 1912, cliii, 473.
[2] Deutsch. Ztschr. f. Chir., September, 1911.



The Relation of the Lymphatics of the Gall-bladder to the



Duodenum and Pancreas of Newly-born Dog, Injected to Show Lymphatics. In Many Places an Intimate Connection Exists between the Pancreatic and Duodenal Lymph Systems. (After Bartel.)

creatic head. Indeed, he was able to inject from the gall-bladder the lymphatics of the upper part of the head of the pancreas, the portion which we have seen is most frequently involved in association with biliary disease.

Bartels was acute enough to suggest the possibility of transmission of disease from the duodenum or neighboring organs to the pancreas but possessed no illustrative clinical material. Arnsperger[1] reported several cases of this type, ascribing the condition of the pancreas to a lymphangitis, and we have urged the adoption of the term, pancreatic lymphangitis, to apply to this condition as most descriptive both of its origin and its nature, and as covering the most common inflammatory condition met in the gland.

At operation the sequence of events is often clearly pointed out as follows: cholecystitis, lymphangitis and lymphadenitis, observed in the gastrohepatic omentum along the course of the cystic and common ducts, peripancreatic lymphadenitis, pancreatic lymphangitis. Herein lies the rationale of the treatment of this form of pancreatitis by measures designed to correct the primary infective process, its subsidence being analogous to that which occurs in the treatment of primary foci of lymphatic infection elsewhere in the body.

As to the subsequent course of such infections of the pancreas it is not yet possible to speak with the certainty of demonstrated fact. But it does not seem too much to assume that here as elsewhere the secondary infection may prove to be more severe and serious than in its primary focus. Delezenne,[2] Polya[3] and others have shown that bacteria can activate trypsin. An infection severe enough to cause necrosis of the parenchyma is also able to activate the ferments, since self-activation occurs after death of the pancreatic cells. Here we have the stage set for hemorrhagic and necrotic pancreatitis.

It has been demonstrated and should be clearly realized by the surgeon that once the pathological ferment activity of the gland is begun no further process, bacterial or otherwise is needed to explain the striking local effects seen in the pancreas and its vicinity in acute pancreatitis, and also the severe and often fatal systemic intoxication. If a portion of dog's pancreas be removed during life and again under sterile conditions be dropped into the abdominal cavity of a second dog, this animal will probably be dead within twenty-four hours, with all the symptoms of a severe prostrating toxemia and within the abdomen will be found fat necrosis and a quantity of "dirty" exudate (Sweet[4]). In the autolyzed pancreas Lattes[5] found a substance able to activate pancreatic juice or, in other words, to change the fresh secretion, which is unable to act upon protein, to a state in which it attacks protein with great violence, injuring it if living, digesting and dissolving it when dead. This activating substance is more stable toward heat

[1] München. med. Wchnschr., 1911, liii, 729.
[2] Compt. rend Soc. de biol., 1902, liii, 164.
[3] Mitt. a. d. Grenzgb. d. Med. u. Chir., 1912, i, 49.
[4] Surgery of the Pancreas, 1915, Philadelphia.
[5] Virchows Arch., 1913, ccxi, 1.

than the proteolytic ferment, and can be obtained free from ferment by heating to 60° C. for fifteen minutes. Now, if to sterile inactivated pancreatic juice a portion of the activating fluid be added and the mixture injected into an animal the typical fatal intoxication occurs. The activating substance may be destroyed by heating to 75° C. for fifteen minutes. Adding to inactivated pancreatic juice the autolysate which no longer possesses the power of activating trypsinogen, and injecting this fluid into an animal, nothing happens except a transitory fall in blood-pressure, which is a non-specific consequence of injection of organ extracts. From this and a large amount of work by other observers the conclusion is irresistible that activated ferment action is the key to the clinical and pathological picture of acute hemorrhagic pancreatitis. Fat necrosis is the visible sign of activity of the fat-splitting ferment. This process, however, generates no toxins. It is in the proteolytic process that the poisonous decomposition products are liberated which cause systemic intoxication. The condition, therefore, is one of pancreatic poisoning (*Pancreasvergiftung*).

If the infection is not sufficiently severe to inaugurate this more serious outcome it may yet be able to maintain itself upon an independent footing causing interlobular inflammation and that series of alterations of the gland to the end-results of which we have given the name chronic interlobular pancreatitis. Whether or not this is related to interacinar pancreatitis is still uncertain.

Classification.— As a classification of pancreatitis which conforms more closely to the clinical conditions than any heretofore given we would propose the following:

Acute pancreatitis	*a.* Lymphangitic	
	b. Hemorrhagic	
	c. Gangrenous	
	d. Suppurative	Primary Secondary
Chronic pancreatitis	*a.* Lymphangitic	
	b. Interlobular	
	c. Interacinar	
	d. Diffuse or cirrhosis of the pancreas.	

The more we see of pancreatitis the more do we realize that here as elsewhere there exist all grades and variations of the process. Hemorrhage may be extensive, sudden and diffuse, or it may be slight and localized. Severe inflammation may occur unaccompanied by hemorrhage. Gangrene, as recognized by Fitz, is but the outcome of hemorrhagic necrosis; it may be partial or complete. Suppuration may be a sequel of gangrene, the necrotic tissue affording an opportunity for development of the causative infection or inviting secondary invasion. Suppuration, on the other hand, may be localized to a single focus or be scattered through the gland as multiple foci. *Pancreasvergiftung* is not commonly associated with this form of suppurative pancreatitis. Fat necrosis is often absent even in severe affections, or it may be widespread in what is apparently a less marked condition of pancreatic

inflammation. Slighter degrees of involvement grade off into the most inconspicuous lesions. In its less severe and less characteristic forms pancreatitis is a common disease and its symptoms are as a rule, misinterpreted.

Acute Pancreatitis.—Acute pancreatitis may be subdivided pathologically into:

1. Simple non-suppurative { Lymphangitic. / Hematogenous.
2. Primary suppurative.
3. Hemorrhagic.
4. Gangrenous.
5. Secondary suppurative.

All these varieties may be localized, spreading or diffuse.

The inflammations which affect the pancreas are modified in many instances by the phenomena of hemorrhage and fat necrosis as previously noted. These are conditions peculiar to this gland since they result from its own specific composition and activity. Their importance in the history of the development of our knowledge of the subject, the aid which they give in diagnosis and their association with the most spectacular instances of acute pancreatitis, have all served to focus attention chiefly upon that form of acute inflammation which is characterized by these phenomena. It should be recognized, however, that acute pancreatitis can and does occur without either or both of these accompaniments.

Simple Non-suppurative Pancreatitis.—Acute pancreatitis may present itself as a simple inflammatory affection showing the usual signs of inflammation, namely, swelling, edema, congestion and perhaps associated tenderness, if the organ be palpated. At operation this type of pancreatitis is seen most often affecting the head or a portion of the head of the pancreas.

It may, however, be diffuse with swelling of the whole gland. As seen by the surgeon it is always accompanied by cholelithiasis, cholecystitis, duodenal ulcer or duodenitis, and the weight of evidence and analogy points conclusively to the fact that this type of the disease is the result of infection involving the pancreas possibly by way of the ducts, but in more instances doubtless by way of the lymphatic intercommunication with neighboring infected viscera. That toxic processes and infections reach the gland also by way of the blood stream is certain. It is probable that this occurs at times in mumps, scarlet fever, diphtheria and many other general infectious diseases in the course of which many observers have reported clinical conditions that can hardly be interpreted otherwise than as a complicating acute pancreatitis. Thus, Goldie[1] reports five illustrative cases in children ranging from five to nine years of age. Two cases were in the midst of an attack of scarlatina. One case was convalescing from the same disease and had developed chicken-pox, and one had faucial diphtheria.

[1] Lancet, 1912, ii, 1295.

All the cases had an associated rhinorrhea. Suddenly there was complaint of abdominal pain, usually nausea and vomiting with swelling of the upper abdomen and tenderness over the head of the pancreas. Jaundice and clay-colored stools followed promptly. Gradual recovery ensued in all cases. Robson and Kehr have suggested that the disease, commonly known as catarrhal jaundice, is in reality pancreatitis with resulting obstruction of the common duct. Such conditions are neither surgical nor fatal, so that as yet the autopsy *in vivo* or postmortem is lacking as confirmatory evidence of the pathological basis. We feel safe, however, in saying that clinical observations point to the possibility that simple inflammation of the pancreas is not rare, occurs often in early childhood, and like chronic nephritis is now recognized as a long-deferred sequel of scarlet fever in certain cases. Likewise certain scleroses of the pancreas, first observed in recent years will no doubt be ascribed to a process inaugurated by earlier infective pancreatitis.

It is worthy of note that at least a part of the symptoms now ascribed to gall-bladder or duodenal disease must be due to the associated pancreatitis. The marked swelling of the pancreas sometimes found at operation is certainly productive of symptoms though it is usually impossible to separate the pancreatic from the biliary symptoms.

The profession is still napping in respect to the realization of the actual frequency of pancreatic disease. We have been misled by the infrequency with which pathologists have found postmortem evidence of disease of the pancreas. This is due to several reasons. The tendency of the gland to digest itself after death soon destroys all evidences of any parenchymatous changes. The supposed immunity of the pancreas to disease has caused it to be slighted in routine examinations. Again, most instances of less severe pancreatic disease are not diffuse but affect only a portion of the gland which may easily be missed in the specimen removed for study. Finally, there is evidence that an extensively diseased pancreas may so recover itself that demonstration of previous inflammation is difficult. Thus Körte reported a case which he operated upon in 1895 before the characteristic appearance of the disease had become known. Fat necrosis and serosanguineous exudate were present. The abdomen was closed without attacking the pancreas. The next year, having to operate on the same patient for a stone in the common duct, the pancreas was investigated and found normal in size, appearance and consistency. Other observers have had similar experiences. The pancreas therefore should be more often thought of in connection with upper abdominal disturbances, whether mild or severe.

Primary Suppurative Pancreatitis.— Primary suppurative pancreatitis is the result of pyogenic infection. The term primary is used in this connection to distinguish the condition from that form of suppurative pancreatitis in which the suppuration represents the natural termination of gangrene of the gland, whether primarily infective or not. The simple type of lymphangitis, above described, does not often suppurate. Like the salivary glands the pancreas is resistant to abscess formation.

Occasionally, however, conditions are such that abscesses, usually multiple, sometimes single, will form within its substance. Obstruction of the duct of Wirsung is a strong predisposing factor. We have observed at autopsy one case of multiple pancreatic calculi and one case of gall-stone impacted in the papilla of Vater associated with multiple abscesses scattered throughout the pancreas. We have seen one case (at operation) of single abscess in the head of the pancreas of a child developing during convalescence from acute suppurative appendicitis and peritonitis. In neither of these cases was there evidence of previous hemorrhage or necrosis. Dieckhoff reported similar cases and drew the conclusion that such processes represent the advance of infection from the larger to the smaller ducts into the substance of the gland where they set up multiple foci of suppuration. He believes that the infection gained entrance to the duct of Wirsung from the duodenum and suggested that this could readily happen after the entrance to the duct had been dilated by the passage of a gall-stone. The presence of an irritant such as a stone with the stasis which it might cause could very very readily be conceived as the cause of an infection of the duct, more or less grave in character, and in this case the route of travel of the infection would be along the duct, whether on its surface or in the subepithelial lymphatics makes little difference. It seems probable at the present time that infections other than those of the duct can give rise to suppuration. In the case of single abscess of the head of the pancreas occurring secondary to suppurative appendicitis, a more plausible explanation is infection by way of the retroperitoneal lymphatics. Hemic infection cannot be ruled out.

Hemorrhagic Pancreatitis.—Though Rokitansky[1] in 1863 and Klebs,[2] in 1869 had described the condition of acute hemorrhagic pancreatitis, it was not until the publication of Fitz (in 1882) that attention was called to its frequency and importance. This curious condition has been the subject of much speculation and investigation and only recently has the problem seemed to be in a fair way of solution. The hemorrhage may be sudden and profuse overshadowing all evidences of infection or other injury to the gland. In other cases it is clearly but the accompaniment of a train of pathological changes which are recognizable as inflammatory in character. These marked differences in clinical behavior led Fitz, and many others after him, to recognize pancreatic hemorrhage as a condition independent from hemorrhagic pancreatitis. Mayo Robson has proposed that hemorrhagic pancreatitis be divided into two groups (*a*) ultra-acute, in which the hemorrhage precedes the inflammation, the bleeding being profuse and both within and outside the gland; (*b*) acute, in which inflammation precedes the hemorrhage, which is less profuse and is distributed in patches throughout the gland. The name of Pancreatic Apoplexy has been employed to emphasize the non-inflammatory nature of the simple hemorrhagic process. Robson has pointed out a general tendency to hemorrhage

[1] Lehrbuch d. path. Anat., Vienna, 1863, iii, 313.
[2] Handbuch d. path. Anat., Berlin, 1869, i. 217.

associated with lesions of the pancreas as evidenced by ecchymoses and at times extensive spontaneous hemorrhage at a distance from the pancreas. Experimentally hemorrhagic pancreatitis has been produced by an extraordinary variety of methods. Lattes[1] has summarized these various experiments which have resulted in hemorrhagic pancreatitis with its accompanying clinical manifestations as follows: artificial ischemia (Blume, Oser, Milisch, Lewit, Wulf), injection of various substances into the duct: oil (Oser, Hess, Guleke, Eppinger), bile (Guleke, Flexner, Opie, Oser, Polya), hydrochloric acid and intestinal secretion (Flexner and Pearce, Hildebrand, Rosenbach), intestinal secretions and activated pancreatic juice, commercial trypsin, calcium and sodium chloride (Polya), papain (Carnot), adrenalin (Rosenbach), zinc chloride (Thiroloix, Oser) sulphuric acid, chromic acid, formalin, soda (Flexner), or into the vessels (air, paraffin, wax, lycopodium, oil) (Panum, Lépine, Bunge, Guleke) and by ligation of all pancreatic ducts during digestion (Hess), mass ligation and gross injury to the pancreas (Katz, Winkler). The introduction of pathogenic bacteria will at times accomplish the same result. Recently Sweet[2] in a well-considered paper based upon the literature and the results of his own experiments has pointed out that the single and efficient factor common to all such conditions is the liberation of trypsin. Deaver and Pfeiffer,[3] arguing from anatomical and physiological facts and clinical observations, had reached a similar conclusion. Normally the proteolytic ferment exists in the gland and its duct as a proferment or zymogen. In this condition it is incapable of acting injuriously upon the tissues with which it comes in contact. When activated, however, it becomes a highly destructive agent and when brought into direct contact with the tissue proteids it not only causes necrosis but proceeds to digest and liquefy the tissues attached. Injury to the bloodvessels causes diapedesis of the red cells as well as the leukocytes. Actual erosion of the vessels gives rise to free hemorrhage of greater or less volume according to the size of the vessels that are opened. In this light it is readily understood that a small focus of diseased or injured pancreatic tissue could cause an extensive hemorrhage entirely obliterating all marks of the seat and the nature of the primary insult. Normally the trypsinogen of the pancreatic secretion is activated by the enterokinase of the duodenal contents, a consideration which has led to the suggestion that pancreatitis may be the result of intraglandular activity of its own ferments induced by the regurgitation of duodenal contents into the duct. It is, however, quite unnecessary to assume that enterokinase must be present in order to convert the proferment into its active state since this may be accomplished by other means. Delezenne[4] and Hekma[5] have shown that an activating substance is present in many varieties of bacteria and Lattes[6] finds a similar substance in normal pancreatic

[1] Virchows Arch., 1913, ccii, 1.
[2] Internat. Clinics, vol. iv.
[3] Ann. Surg., 1913, lviii, 151.
[4] Loc. cit.
[5] Arch. f. Anat. u. Entwcklng., 1904, p. 343.
[6] Virchows Arch., 1913, ccii, 1.

PLATE XIII

Acute Hemorrhagic Pancreatitis Showing Fat Necrosis and Gangrene.

tissue that has undergone self-digestion. Mellanby and Wooley[1] have shown that calcium, barium and strontium salts, neutralization with hydrochloric acid, precipitation of the juice with alcohol and resolution of the precipitate, all activate the pancreatic ferments. They put forth the hypothesis that enterokinase in varying amounts is always present in pancreatic secretion, but is inhibited by the alkalinity. Neutralization permits activation. As necrosis is always accompanied by acid formation and many bacteria generate acid it is evident that innumerable combinations of injury, chemical, bacterial and traumatic, can cause activation and interstitial liberation of trypsin which is sufficient to explain hemorrhage, necrosis and fatal intoxication of the subject. We subscribe to the conclusions of Sweet[2] that:

1. No other explanation covers the clinical cases associated with infection and the clinical cases associated with traumatism of the gland.

2. No other explanation affords an understanding of the fact that injury to the gland during digestion is more serious than injury at other times.

3. The picture of an acute pancreatitis can be fully reproduced by placing the sterile pancreas of one normal dog into the belly of another normal dog; or

4. By isolating a portion of the dog's own pancreas from its blood supply.

5. The ducts of the pancreas can be tied without causing anything but simple sclerosis; but

6. A fatal pancreatitis may follow the ligation of the ducts, if any great amount of gland tissue is so included in the ligation of the ducts that autolysis occurs in the ligated bit of tissue (own experiment).

This view reconciles differences of opinion based on varying clinical conditions. Injury of the pancreas may cause necrosis and set in motion the destructive effects of ferment poisoning or it may fail to do so. Infective processes also may spread their effects in the gland without setting up this condition for diffusion and activity of the ferments or they may show themselves chiefly in the initiation of hemorrhage and *pancreasvergiftung*. Fat necrosis may occur without hemorrhage by diffusion of the pancreatic juice containing lipase which requires no activator, the trypsinogen remaining inactivated and inert.

Fat Necrosis.—The observations of Balser[3] and Fitz's[4] suggestion and the work of Langerhans,[5] Flexner and others have established the fact that these distinctive, opaque, whitish or yellowish flecks seen most often in the peripancreatic fat but occasionally widely disseminated throughout the abdomen or even in the subcutaneous fat are the results of digestion of these areas of fat by the lipase of the pancreas. The fat is split into glycerin and fatty acids. The glycerin is absorbed and the fatty acids combine with the calcium of the blood and tissue juices.

[1] Jour. Physiol., 1913, xlvi, 171.
[2] Loc. cit., p. 36.
[3] Virchows Arch., 1882, xc, 520.
[4] Med. Record, 1889, xxv, 197.
[5] Virchows Arch., 1890, cxxii, 252.

The resulting appearance is characteristic and is, practically speaking, pathognomonic of a lesion of the pancreas.

Just as hemorrhage or fat necrosis or both may be entirely absent in acute pancreatitis, so do we find that the part they play may be more or less prominent. Hemorrhage may be small in amount, localized to one spot or distributed in multiple foci throughout the gland, or it may diffuse through the entire pancreas which will be found immensely swollen and as red as beef or it may occasion large hemorrhages in the neighborhood of the gland with accumulation of blood beneath the peritoneum and infiltrate into the mesenteries and omenta. In the most severe cases a serosanguineous exudate is usually found in the peritoneal cavity.

Gangrenous Pancreatitis.—Gangrenous pancreatitis under clinical conditions is a sequel of the hemorrhagic condition. Doubtless it depends upon very much the same conditions as hemorrhage. It is quite likely that a certain amount of necrosis involving bloodvessels is a prerequisite of hemorrhage. However that may be, the hemorrhage which follows is frequently sudden and massive, involving a large part or the whole of the gland. The resulting disturbance plus ferment activity determine the death *en masse* of more or less of the tissue and a sphacelus. The prognosis is very closely connected with this process. So violent may be the initial trauma and the activities to which it gives rise that the doom of the patient is sealed. Practically the entire pancreas undergoes rapid destruction and the picture of fatal *pancreasvergiftung* develops at once and in spite of any efforts to prevent it or abate its effects. If the extent of pancreatic injury and resulting intoxication falls just short of being lethal the patient survives the immediate effects only to harbor a gangrenous mass which invariably is or becomes infected and can be relieved only by drainage and sequestration. The chances of recovery from such a condition involving the cellular retroperitoneal tissues, formed with such rapidity that encapsulation is impossible, involving the most essential structures found in this location and so situated that efficient drainage of exudate and sloughs is difficult or impossible, is reflected in the high mortality.

Secondary Suppurative Pancreatitis.—Secondary suppurative pancreatitis is in turn a sequel of hemorrhagic necrosis. It is distinguished from primary suppurative pancreatitis in that the latter is suppuration within the pancreas and the former is suppuration of the pancreas. It is the natural consequence of gangrene and in a sense is salutary in that by softening and disintegrating the gangrenous tissue and by following the well-known characteristics of pus it tends to search for an exit, thus providing a means for the evacuation of the diseased process.

Retroperitoneal gravitation abscesses may form in the left loin and very rarely in the right loin. The lesser peritoneal cavity may be converted into an abscess sac. Occasionally, the gastrohepatic omentum is penetrated and an abscess may form above the stomach and beneath the liver, as in one of our cases, or it may spread upward over the liver, forming a subdiaphragmatic abscess. A generalized

peritonitis may occur but is less common than localized abscess in one of the situations mentioned. A great difference exists in the toxic and digestive properties of such collections. While at times they spread rapidly and increase greatly in size, they may, on the other hand, become stationary, encapsulated and recede. Or they may very slowly enlarge making themselves known finally as a pseudocyst.

Abscesses after localization may ulcerate into adjacent viscera or into the general abdominal cavity. Körte has met with 3 cases in which the abscess ruptured into the duodenum or colon and 3 in which rupture took place into the general peritoneal cavity.

An appreciation of the vast number of permutations of these processes will enable one to understand quite readily the clinical differences which are to be expected in different cases.

Symptoms and Diagnosis.—Acute pancreatitis in its classical form with hemorrhage and extensive involvement is one of the most agonizing seizures known to mankind. Sudden and serious collapse may occur. As a rule, when the patient is first seen collapse, if present at the onset, has passed, though the pain remains intense. So great is its severity that the patient is unable at times to ascribe to it a definite locality except that it is abdominal. It overflows its natural courses and irradiates all the adjacent spinal segments. Usually it is clear that the maximum intensity is in the epigastrium. At times it is felt chiefly in the right hypochondrium, less frequently in the left hypochondrium and occasionally it pierces through to the back and lumbar region and radiates into the chest or into the iliac fossa.

In the early stages the pulse and temperature are usually subnormal or normal, contrasting strangely with the evident seriousness of the condition. Only later, with the onset of infection, toxemia or weakness do the pulse and temperature rise. Finally, as in most terminal conditions the pulse becomes very rapid and there is a marked rise of temperature. So uniform are the primary slowing of the pulse-rate and the subnormal or normal temperature that they possess considerable diagnostic importance.

Vomiting is an early and persistent symptom. Usually the patient vomits the contents of the stomach with the initial pain. Thereafter uncontrollable nausea and vomiting come on at intervals. After the first insult the vomitus is usually less in amount and biliary in character. Never does it become fecal unless the paralytic ileus of peritonitis follows as a result of the pancreatic extravasation and infection, in which case it represents the usual regurgitant vomiting of peritonitis and is an evidence of impending death. Rarely vomiting may be absent.

Halsted first drew attention to a peculiar cyanosis which was present over the abdomen in one of his acute cases and other observers have observed the same appearance in a considerable percentage of cases of ultra-acute pancreatitis. The cyanosis, however, is not limited to the abdomen but may be seen in the face or other portions of the body.

As a rule, when first seen by the surgeon some hours or days after

onset, rigidity of the abdominal muscles is not extreme. There is rather a marked feeling of resistance in the epigastrium and perhaps an indefinite mass extending transversely across the upper abdomen in the region of the pancreas. There may, however, be pronounced rigidity, as in one case seen by us within four hours after the attack in which the whole abdomen was boardlike as is more commonly seen in perforative peritonitis, a diagnosis which the circumstances induced us to make in this case. Possibly, if more cases were seen immediately after onset, rigidity would be more often noted as a reflex phenomenon associated with the severe primary injury to the pancreas and its immediate surroundings. It remains true, however, that after a time there is less rigidity than resistance. Deep pressure over the region of the pancreas causes pain and spasm. Light pressure is not so much resented as it is in perforative peritonitis.

Meteorism of the upper abdomen soon appears. That region is seen and felt to be more prominent and distended than the lower abdomen, later this difference disappears as general peritoneal irritation causes paralysis and distention of the intestines. After emptying the bowel by enema this difference at times may again appear. The bowels are usually obstinately constipated, though at times and in certain stages diarrhea may be present owing to irritation of the pelvic colon and rectum.

The leukocyte count may be normal but is more often increased and in general the longer the duration of the condition and the more marked the associated infective processes, the higher the leukocytosis. It tends to be lower, however, than in most conditions likely to be confused with it.

We have observed in a number of instances that the percussion note over the bases of the lungs, particularly on the left side, shows considerable impairment. The cause of this phenomenon is not entirely clear. Whether it is due to atelectasis of the base due to restricted movements of the diaphragm or to the accumulation of a small amount of serous fluid within the pleura or to both, we have not been able to demonstrate. One must not lose sight of the fact that an accumulation of exudate in the lesser peritoneal cavity, not an infrequent occurrence, might cause impairment of the percussion note at the left base, and also that owing to the proximity of this intensely irritating material to the diaphragm its pleural surface may be involved and throw out a quantity of serum into the pleural cavity. When this phenomenon is recognized and understood it may be of some assistance in diagnosis, but we have known it to obscure the real state and to lead to an erroneous diagnosis of diaphragmatic pleurisy or pneumonia affecting the lower lobe. Jaundice is not often pronounced, but an icteroid hue of the skin with slight tingeing of the sclera is not uncommon. It may be entirely absent. Hiccoughing may be very troublesome in some cases. In one case, personally observed in the University Hospital under Dr. Stengel's care, it was the obstinate singultus that was the chief complaint and brought the patient to the hospital. Death

occurred suddenly shortly after admission. Autopsy showed a gall-stone impacted in the papilla of Vater with multiple abscesses scattered through the pancreas, peripancreatitis and fat necrosis, but no evidence of hemorrhage in the pancreas or its vicinity.

The patient is usually a male in the third or fourth decade of life who is inclined to obesity and gives a history of previous digestive disturbances. Many exceptions exist to these generalities. Acute pancreatitis is about twice as frequent in males as in females. Fitz found 17 males to 4 females, Körte 30 males to 14 females. In 18 cases of this type we have found an even balance, 9 males to 9 females. In extended statistics, however, it is clear that there is a considerable preponderance of males. No reason can be assigned with certainty for this sex incidence and it remains a strange phenomenon that acute pancreatitis, admittedly a disease preëminently associated with and dependent upon cholelithiasis in the majority of instances should occur more often in the sex which is less liable to gall-bladder disease. A plausible explanation can be advanced in the greater frequency of gastric and duodenal disease in males, often due to excesses in tobacco and alcohol.

The age incidence is given as follows by Oser:

Years.	Cases.
1 to 10 (10 days)	1
21 to 30	11
31 to 40	6
41 to 50	6
51 to 60	3
61 to 70	2
71 to 80	1

and by Fitz.

Years.	Cases.
20 to 25	3
25 to 30	1
30 to 35	2
35 to 40	2
40 to 45	3
50 to 55	1
55 to 60	1
60 to 65	1
65 to 74	1

Obesity more or less marked is a feature of about two-thirds of all cases.[1] Alcoholism is a frequent but by no means invariable factor. A rather noteworthy feature is the association of pancreatitis with pregnancy or the puerperium in women. Arteriosclerosis has been alleged to be a predisposing factor, principally by those who contend that vascular disease is primarily responsible for pancreatic hemorrhage. Clinical analyses do not appear to bear out this contention. Jenckel[2]

[1] Wilms (München. med. Wchnschr., 1918, lxv, 204) called attention to the infrequency of acute pancreatitis in Germany during the great war and suggested a relationship to the lack of fat in the dietary.

[2] Verhandl. d. deutsch. Gesellsch. f. Chir., 1914, xliii, 157.

reports two cases of acute hemorrhagic pancreatitis occurring two days after: (1) resection of the sigmoid for carcinoma; (2) removal of an ovarian cyst. Hoffman, quoted by Seidel[1] reported 3 cases of acute pancreatitis following operation for (1) appendicular abscess, (2) appendicular peritonitis, 2 cases. We have observed abscess of the head of the pancreas in a child occurring after operation for appendicular peritonitis. In our view these are instances of retroperitoneal lymphatic infection.

No one of these signs or symptoms nor any combination of them will unfailingly make one aware of the existence of acute pancreatitis. Morrison has correctly placed the mental attitude when he wrote that "if the history, symptoms and signs do not exactly fit acute intestinal obstruction, or stomach or duodenal perforation, perforated appendix or acute cholecystitis, and yet have some resemblance to each of them, pancreatitis is the most probable cause."

In the more severe cases the severity of the initial symptoms, the obstinate vomiting, the slow pulse-rate, the low fever or its absence, the appearance of a tumefaction in the epigastrium, or even more characteristic when present, the signs of an inflammatory mass in the loin, will point with a considerable degree of certainty to acute pancreatitis.

The *differential diagnosis* is concerned chiefly with the conditions mentioned above by Morrison. It must be admitted that a positive distinction cannot always be made and many cases are operated upon under the wrong clinical diagnosis. This error is not often serious in view of the fact that all these conditions call for prompt operation and the correct surgical diagnosis is now promptly made from the well-known characters of the exudate with fat necrosis and the palpable enlargement of the pancreas. The gastric crisis of late syphilis should be considered and excluded by history and examination of the pupillary reactions and the reflexes. The Wassermann reaction should be made in all cases when time permits. It is not wise to wait for the time-consuming investigation of pancreatic activity, which when obtained is far from conclusive. Loewi's pupillary mydriasis reaction is simple and rapid; Glaessner[2] reports a case in which a positive reaction confirmed this opinion. Its value is as yet uncertain. When positive it is not pathognomonic of pancreatitis. Most observers agree that the Cammidge reaction is unreliable. In our hands it has been of no assistance. Glycosuria is suggestive when present, but is very variable in the frequency of its appearance. Thus Körte found it in 8 of 44 cases while in our 18 cases it was present in none at the time of operation, though one patient who lost a large portion of his pancreas by necrosis, afterward died of diabetes.

Treatment.— Acute pancreatitis is not invariably fatal without operation, a fact which has been established by our increased knowledge concerning the variation in the severity and extent of the lesions. It

[1] Arch. f. klin. Chir., 1913, lxxxv, 384.
[2] Deutsch. Klin., 1913, xiv, 256.

is not very infrequent in cases operated upon for acute pancreatitis to find a history of one or more similar seizures, from which temporary recovery ensued. Certain pseudocysts of the pancreas are in reality instances of recovery from acute pancreatitis, the residuum of the process forming the basis for the cyst. Again, cases in every way identical clinically with those known to be pancreatitis, with glycosuria and evidence of pancreatic insufficiency connected with the attacks, have been known to recover perfectly without operation, or in still other instances after a period of waning health due to diabetes following immediately or shortly after the attack, have come to autopsy and revealed the evidences of previous severe pancreatitis—atrophy of the organ, interstitial fibrosis or stone impacted in the head of the pancreas. The original prognosis of Fitz therefore was too pessimistic and the estimate of Musser of 100 per cent. mortality without surgical treatment was too high. Still, in the truly severe cases it is certain that recovery without operation is rare. There is no medical treatment which can in any way influence the chief factors upon which the prognosis depends, namely, the extent of the destruction of the pancreas and the absorption of the toxic products engendered by the ferment activity abetted by infection. We may safely conclude that the cases that recover under expectant treatment, for medical treatment is nothing else, would also recover if submitted to operation, while of those that die without operation at least a certain proportion would survive as a result of the assistance which appropriate surgical procedures give the body in dealing with the process.

The operative mortality in severe cases is also high. Körte in 34 cases had 18 recoveries and 16 deaths (47.4 per cent. mortality). In collective statistics he found the mortality to be 60 per cent. Dreesmann, in 1909, collected 118 operative cases with a mortality of 55 per cent. Of these, 40 cases operated upon early, showed a mortality of only 20 per cent. Mettin, reporting 22 cases of Neumann, found the mortality to be 69 per cent. In 18 cases we have had 12 recoveries and 6 deaths (mortality $33\frac{1}{3}$ per cent.).

To understand the various procedures which are of use in pancreatic surgery we must be able to answer several questions, (1) what may we aim and legitimately hope to accomplish by operation; (2) when should we operate; (3) how should we operate?

It is obvious that partial or total resection of the inflamed pancreas is out of the question. The disease cannot be removed *in toto*. It should be the aim of the surgeon to prevent the further development of the condition and so far as possible to relieve the body from the task of caring for its products. Can any beneficial effect be exerted by treatment of the cause? Unfortunately the exact determining cause of the majority of cases of acute pancreatitis is not at once apparent and, again, we have seen that experimentally at least, the initial injury sets in motion a train of circumstances that proceeds to the most severe consequences even after the cause is no longer active. Unquestionably any apparent cause should receive appropriate treatment, if the con-

dition of the patient warrants. We know definitely that in some cases one effective mechanical cause consists of the presence of a stone impacted in the papilla of Vater. It is not too much to hope that in the event of such a cause being recognized removal of the stone and relief of the back pressure upon, and regurgitation of, the bile into the pancreatic duct would have a beneficial influence. Stones in the common duct should arouse suspicion that this mechanism is or has been acting, and their presence justifies choledochotomy with removal of the stones from the duct and the passage of a probe to make sure that its outlet is patulous. In 6 cases Körte found stones in the common duct, 3 of which were at the top of the papilla of Vater. Two of these he removed at operation and 1 was removed at autopsy.

In a case operated upon recently the patient, a man of spare physique, aged forty-two years, was suddenly seized with violent epigastric pains followed by vomiting. When first seen he was suffering intensely, and was in partial collapse. The physician who was called in gave him a huge dose of morphin and sent him to the hospital (Abington Memorial), where he was admitted within four hours after the attack began. Two hours later he was operated upon, his condition at that time being somewhat more comfortable. The abdomen was generally rigid as a board. There was tenderness in the epigastrium but no distention. A diagnosis of perforated duodenal ulcer was made. On opening the abdomen the stomach and duodenum were normal. There was a small amount of free serous fluid in the upper abdomen. The gall-bladder contained numerous small stones and several could be felt in the common duct. These structures showed no signs of acute inflammation. The pancreas was enormously swollen throughout and the adjacent areolar tissue and omenta were thickened and edematous. No hemorrhage being present, the pancreas was not opened, but the stones were removed from the gall-bladder and the common duct, both of which were drained. A probe was passed down into the duodenum thinking perhaps to dislodge a calculus in the papilla. There was no evidence of this nor could any stone be discovered subsequently in the feces. Convalescence was uneventful. It is possible that a stone had been impacted in the outlet but had slipped back into the dilated portion of the duct.

Stones in the gall-bladder, on the other hand, do not act mechanically upon the pancreas. Yet they are by far the most common finding in acute pancreatitis, and it is impossible to escape the conclusion that in some manner they are responsible for the inauguration of pancreatitis in at least a large proportion of cases. Much less frequently simple, non-calculous cholecystitis is found. In our 18 cases gall-stones were present 15 times. In one case it was impossible to determine the condition of the gall-bladder, the incision being in the left loin. Körte found that in 44 cases personally observed disease of the gall passages was present in 22 (50 per cent.); 21 cases showed cholelithiasis and one non-calculous cholecystitis. Osler found in 105 cases of pancreatitis 45 instances of complicating cholelithiasis. Egdahl

found an exactly similar relationship. Quénu in 128 collected cases found 47 instances of gall-bladder involvement. The role of gall-stones in the gall-bladder may very well be a primary one through the exacerbations of inflammation which are a well-known accompaniment of cholelithiasis. Holding, as we do, the view that pancreatitis is in many cases the result of an inflammation propagated from the gall-bladder, we feel that it is highly desirable in every case, conditions permitting, not only to remove any stones that are present in the gall-bladder but also to drain it for the influence that drainage exerts over infection in its walls. Exceptionally, the gall-bladder may be removed and the common duct drained, but, as a rule, the surgeon should content himself with drainage of the gall-bladder which is safer, quicker and answers every temporary indication. It is rarely true that any case which can stand operation at all will not at the same time permit of the simple operation of opening and draining the gall-bladder. We have performed cholecystostomy in 11 cases with 3 deaths; cholecystostomy and choledochotomy in 2 cases both of whom recovered and of 4 cases in which the bile tract was untouched 2 died and 2 recovered. One case collapsed and died on the table before anything but the abdominal incision had been done. We have not been able to attribute any of the deaths to the operations upon the bile passages. It seems likely that the relief of the bile tension in the ducts acts in certain cases in a favorable manner. Without being able therefore to assert that the original cause of the pancreatitis continues to act from the bile passages as a base, or to explain in an incontrovertible manner the *modus operandi* of action it is nevertheless our belief that no transperitoneal operation for pancreatitis is complete without (*a*) opening the bile passages and removing any stones that are found, and (*b*) assuring one's self of the patulous condition of the common duct and (*c*) establishing drainage. Experience and the proper circumstances are assumed, for time is precious in these cases.

In the presence of associated duodenal ulcer or duodenitis, nothing in an operative way can be done to relieve these conditions though they may be the starting point of the entire process. We can only hope that the cause has ceased to act, and direct our attention to the relief of the pancreas and the conditions to which it may have given rise. In other instances, no clue to the origin of the process will be demonstrable and in these also, as well as in cases of gall-bladder disease, just discussed, the question arises as to the proper procedure to employ upon the pancreas and peripancreatic tissues. The answer to the question will depend largely upon the conditions present and these in turn upon the severity of the attack, over which we have no control, and the stage of the disease. Is it advisable to attack the condition at the earliest possible moment or should one wait for more favorable local and general conditions? Formerly, in common with many other surgeons, we counselled early operation but advised against operation in the presence of shock. If we now except the primary fainting attack

which may come on from the excessive pain and is rarely seen by the physician and practically never by the surgeon, we would say operate immediately whatever the condition of the patient. Salt solution and other stimulants may be given if necessary, but it is essential to go in at the earliest possible moment. The reason for this is seen in the type of shock from which these patients suffer. It is not a temporary phenomenon of nervous origin but results from the effects of the toxemia (*pancreasvergiftung*). It is essential, therefore, to operate for the relief of absorption. It may be possible also to spare the pancreas from further injury by instituting drainage. Körte's tabulation of the results of operation according to the duration period of the disease shows the distinct superiority of early over deferred operation.

	Recovered.	Died.	Total.
During the first week after the onset	8	4	12
" second " "	3	1	4
" third " "	4	3	7
" fourth " "	3	4	7
" fifth " "	0	4	4

Our own results are substantially in agreement with the above.

	Recovered.	Died.
First week	8	4
Second week	2	0
Third week	1	1
Fourth week	0	2

The logical conclusion therefore from our knowledge of the nature of the disease and the results of early as compared with deferred operation, is that operation should be done at the earliest possible moment. The sicker the case the greater the need for operative relief. In following this rule in one case we had a death on the table. We do not feel, however, that such an occurrence militates against this advice since the majority of cases will die within a few days even if not operated upon, and while the attempt to save desperate cases may precipitate a fatality in some that are already doomed, it will rescue others who would have had little chance without it.

What should be the method of procedure in dealing with the pancreas and its exudative products? One of the first cases of recovery from acute pancreatitis was reported by Halsted who did nothing more than to sponge out the serosanguineous exudate. A number of similar cases have been reported since that time. It is probable that such cases should be reckoned more as medical than as surgical recoveries. Whipple[1] has shown, experimentally, that under certain conditions the peritoneal exudate in acute hemorrhagic pancreatitis is non-toxic and even protective. Every surgeon realizes, moreover, that it is impossible to sponge the peritoneum dry of fluid exudate. And it would be remarkable indeed if the removal of the greater portion of this fluid, even granting that it possesses irritating and toxic qualities under

[1] Surg., Gynec. and Obst., 1913, xvii, 541.

certain conditions as the reddened condition of the intestines may indicate, were often to turn the scale in favor of a patient who still retained behind the peritoneum one of the most virulent and toxic conditions known. At the very best interpretation to be placed upon simple sponging away of exudate even if coupled with peritoneal drainage, we must admit that the pancreatic process must be relatively mild, unaccompanied by the extensive necrosis often seen, and therefore lacking in the essentials which go to make up fatal pancreatic toxemia. Lick[1] reports a case of acute pancreatitis in a woman aged twenty-eight years, who was operated without diagnosis on the second day of the attack. Bloody fluid was found and wiped away. The pancreas felt enlarged but no fat necrosis was present. The subsequent course was stormy and after eleven days operation was again performed and drainage of a large amount of necrotic material from the pancreas was effected through the gastrocolic omentum. The earlier operation did not arrest the process in and about the pancreas. It is worthy of note that, while fat necrosis may be present at the end of twenty-four hours, gangrene and softening of the pancreas is not commonly demonstrable before the third or fourth day. Körte observed only one case which showed spots of softening as early as the fourth day. It is difficult, therefore, in early operations to prognosticate what will be the condition of the pancreas in a few days and in the event of progressive inflammation, destruction or pus formation a second operation will be necessary.

One of our fatal cases is of interest in this connection. E. T., aged thirty years, had complained of pain in the upper abdomen for six years. Pain came in sudden severe attacks and felt like a pressure under the right costal margin anteriorly followed by pain in the back and right shoulder. Attacks at first lasted two to three hours, but of late two to three days. There was much indigestion and flatulence. Chills and fever at times accompanied the pains.

The present series of attacks began about six weeks previously culminating in a most severe seizure the day before admission. The patient was in a state of shock with rapid pulse and low temperature. The face was cyanotic and there was considerable dyspnea. Dulness was noted at the left base posteriorly. The abdomen was distended There was extreme tenderness over the gall-bladder region, and a mass which was regarded as the gall-bladder could be felt in the right epigastrium. The case was regarded as probably one of acute cholecystitis and in view of the general condition it was thought best to defer operation. On the fourth, fifth and ninth days after admission gall-stones were passed by rectum. Eleven days after admission operation was done. The gall-bladder and common duct contained stones, a few flecks of fat necrosis were observed in the omentum but the pancreas felt firm though it was enlarged. Cholecystotomy and choledochostomy were done, the stones removed and drainage placed in both gall-

[1] Deutsch. med. Wchnschr., 1911, ii, 2280.

bladder and common duct. Convalescence was fairly satisfactory though slightly febrile until the thirteenth day when the temperature rose and the patient had a chill, the pulse also rising to 156. Three days later tenderness was noted at the left costal margin in the loin with bulging of the ribs at this point. The stools were oily and contained many fatty acid crystals and a few muscle fibers. There was no glycosuria. Cammidge reaction, which was negative before operation, was positive seventeen days after operation. The day following the discovery of tenderness in the loin an incision was made at this point and a large amount of foul, dark material evacuated. Death occurred the following day. An autopsy was not obtainable, but with the hand in the wound the pancreas could be felt, the body and tail being very necrotic and soft.

At the present time we feel that the pancreas in this case should have been explored and drainage placed in such manner as to conduct away any exudate.

The question of direct drainage of the pancreas and peripancreatic tissues cannot be regarded as settled. Doubtless the relief of tension within and about the gland and the discharge externally of this poisonous autolysates and extravasated ferments are desiderata of the highest importance. Unfortunately the structure of the pancreas is such that limited incision or puncture of its substance cannot be expected to exert much more than a local effect. Also, the situation of the pancreas and its relation to important nerve, vascular and other structures render anything like ideal isolation by drainage a fatuous hope. Still, it remains true that such measures accomplish something and may serve to tide over the acute situation. The peritoneum covering the affected area of the pancreas should be opened. If the typical swollen, beefy appearance of hemorrhagic pancreatitis presents the surface should be superficially scarified and a number of blunt punctures made in its substance. Deep incisions provoke some bleeding and are inadvisable. The surrounding cellular tissues also should be opened cautiously in a few places by a hemostat. Gauze drainage of the affected area should then be instituted either by large cigarette drains or by gauze protected by an enveloping layer of rubber dam. Such drainage should not be removed too soon, but should be allowed to loosen, so as to permit removal without forcible traction.

When gangrenous suppuration is present drainage is always to be employed in amount and character dictated by the well-known principles governing such conditions.

In the case of localized subacute or chronic areas of softening or suppuration simple drainage by tube or cigarette drain in accordance with the conditions will suffice. Körte had two recoveries in this type of case by draining the head of the pancreas from behind after mobilizing the duodenum. It is in the early acute severe conditions, when time and trauma are a very definite factor, that the question and application of the principle of drainage to the pancreas tax the skill and judgment of the surgeon. Drainage here is desirable, but conservation is necessary in its application.

Hemorrhage is a special danger during convalescence. The close relation of the pancreas to numerous large arteries and veins and the erosive action of the exudate make secondary hemorrhage not uncommon. This is an additional reason for not being too active in making incisions in or about the pancreas and packing the neighborhood overly full of gauze. Necrosis of vessels is more likely to occur when they are in contact with drainage. Körte had six fatalities from this cause during convalescence, and another case was saved only by rapid tamponing of the wound. We have been fortunate enough to meet with no fatal hemorrhage from large vessels. One fatal case that was much jaundiced before operation, on the eighth day showed the well-known hemorrhagic tendency seen in that condition, with bleeding from the wound surfaces, gradually growing weaker until death. The pancreas in this case was the seat of numerous small abscesses.

The loin incision is not applicable to acute pancreatitis as such but only to gravitation abscesses or collections in the lesser omentum which are the result of the disease. In these cases it may give excellent service. In one remarkable case recovery ensued after a slough comprising a large part of the body and tail came away. The subsequent history of the patient corresponds with that of a number of other cases who have lost a large part of the pancreas as a result of this disease. For a time he was in good health. In two years sugar appeared in the urine, and four years later he died of diabetes. It may have been a coincidence that his father died of diabetes. Diabetes may follow even when a considerable portion of the pancreas remains and is apparently normal. This but emphasizes the fact that we are not in possession of all the facts concerning the connection of the pancreas with carbohydrate metabolism and therefore do not know at what points the chain may be broken. Robson has suggested that diabetes may at times be cured by operation designed to relieve pancreatic inflammation. While it is true that intermittent glycosuria will often yield to this treatment, we have not observed a case of true persistent glycosuria of the diabetic type that has recovered after operation upon the pancreas or bile ducts.

For the sinuses resulting from drainage expectant treatment will usually suffice. In resistant cases, especially those where the discharge of irritating secretion plays a part in preventing healing, as in the case of sinuses from pancreatic cysts the Wohlgemuth diet is to be recommended.

Chronic Pancreatitis.— Only a decade ago chronic pancreatitis was scarcely considered by the clinicians. Fitz had written appreciatively of the condition and contributions to the subject had been made by Körte, Oser, Lancereaux, Opie, Moynihan, Lenhart, Lazarus and many others, among whom Mayo Robson deserves special mention for his insistence upon the importance of the condition and contribution to its therapy. Still the profession considered chronic pancreatitis a rarity. Opie, from his pathological experience wrote that "the lesion is seldom associated with such definite symptoms that it is recognizable during

life." Robson and Cammidge, on the other hand, attacking the problem from the clinical side, claimed that "from the information obtained from a careful examination of the patient, a knowledge of the history of the case, and the results of a chemical and microscopic examination of the excreta, a correct opinion may be formed in a large majority of these cases." According to our observations the true state of affairs with respect to the possibilities of clinical recognition is located somewhere between these pessimistic and optimistic expressions. Certainly a reasonable certainty of the existence of pancreatic disease may be entertained in a considerable percentage of cases, but it is equally true that our present criteria are too uncertain and inconstant to warrant a claim for great accuracy. What has been gained is the recognition of the fact that the pancreas is not infrequently subject to chronic disease, that it plays a part in the syndrome of much that has been commonly denominated indigestion or attributed wholly to the adjacent viscera, and therefore that in all such cases the pancreas is to be considered and should when practicable be examined carefully in all upper abdominal operations and given a proper valuation in respect to surgical and after-treatment.

Pathologically and histologically we distinguish:

1. Chronic lymphangitic pancreatitis.
2. Chronic interlobular pancreatitis.
3. Chronic interacinar pancreatitis.
4. Cirrhosis of the pancreas (Robson).

It is well to recognize that the last three divisions are based not upon the process of pancreatitis but rather upon its products or end-results. Chronic interlobular pancreatitis shows an increase of the interlobular fibrous tissue with or without evidences of active inflammation. As observed at autopsy the signs of inflammation are usually absent but its results are evident in the deposit of fibrous tissue between the lobules. In interacinar pancreatitis the interlobular septa may be relatively normal while there is within the lobule an increase of fibrous tissue which insinuates itself between the individual acini, usually accompanied by more or less distortion and degeneration of these parenchymatous structures. It is in this form of the disease, as Opie was the first to point out, that the islands of Langerhans are most likely to be affected by atrophic or degenerative processes, a condition especially likely to be accompanied by disturbance of carbohydrate metabolism, which is the chief basis at present for the "island theory" of diabetes. These divisions are not absolutely hard and fast. Intermediate processes exist in which the fibrosis is seen both in the interlobular septa and within the lobules. In such a condition, well advanced, the pancreas is usually reduced in size and firm, giving rise to the term cirrhosis of the pancreas or chronic indurative pancreatitis. Such a classification while useful for descriptive purposes is still lacking in usefulness since the types of lesions here described are not, as yet, correlated with their etiology.

As observed *in vivo* the processes affecting the pancreas have not

been thoroughly studied histologically, but it has been determined that they may affect but a limited portion of the gland, usually the head or a part of the head. Edema, congestion and absorbable exudates may be the only pathology present, all of which may subside leaving no recognizable trace. It seems a fair assumption, however, and one which is based not only upon analogy but upon the clinical history that such processes may inaugurate a series of changes in the gland which will later be recognized as one or the other above-mentioned forms of induration. As yet no complete chain of evidence has been forged to enable us to say just what relation the frequent operative findings of pancreatitis bear to the end-products, but the role of infection is now almost generally considered to be the important agent in the causation of chronic pancreatitis. To cover this localized and early inflammatory change without fibrosis it seems advisable to employ another term. Maugeret, Ansperger, Deaver and Pfeiffer, Sweet and others have called attention to the probability that such changes are in reality a lymphangitis transmitted to the gland from adjacent infected structures and that some gain would accrue if the process were called, as suggested by Ansperger, pancreatic lymphangitis.

Another end-result of conditions that we poorly understand is lipomatosis of the pancreas. Normally there is a small amount of fatty tissue in the pancreatic stroma but occasionally this is enormously increased. In some cases almost the entire pancreas is replaced by fat. It appears to be a replacement process, the fat being deposited as the parenchyma and stroma undergo atrophy and disappear. It accompanies both the interlobular and interacinar types of inflammation but it is uncertain to what extent it depends upon them. In 3 of 90 cases of diabetes described by Cecil advanced lipomatosis occurred in association with interacinar pancreatitis (Opie). It occurs more commonly in the obese, but has been found also in the emaciated (Diechoff, Kasahara, Lépine and Cornil). No relation to surgical disease has been demonstrated.

An etiological classification of chronic pancreatitis is impracticable in the present state of our knowledge. As above stated infection plays the leading role. The avenues by which infection may reach the pancreas are (1) the lymphatics, (2) blood stream, (3) the duct or ducts, and (4) by direct contiguity. Doubtless instances of invasion by each of these portals of entry occur. Occasionally ulceration of the second portion of the duodenum will extend through the wall of the intestine and reach the pancreas immediately adjacent, causing an inflammation of that portion of the organ. The pancreas is able to protect itself against this slow attack by exudate and fibrosis which spare the remainder of the gland. What may occur, however, is well illustrated by the following case.

Mrs. F. C., aged forty-seven years, was admitted to the University Hospital December 22, 1915. She had been perfectly well up to three weeks ago. She then had an attack of severe upper abdominal pain

radiating to the back and both shoulder blades. Two similar attacks since then accompanied by vomiting. She was admitted during an intermission and showed nothing except tenderness in the epigastrium and in both hypochondria.

At operation the gall-bladder appeared normal but contained one small stone. Nothing could be felt in the common duct. The pancreas presented no abnormality. A well-defined chronic duodenal ulcer was present in the anterior wall about one inch below the pylorus. This was excised with the pylorus. The gall-bladder was drained and a posterior gastrojejunostomy made. The stump of the duodenum was implanted into the denuded surface of the pancreas. The patient at first did well, but in about two weeks began to complain of severe upper abdominal pain and vomiting. She gradually lost weight and strength, the temperature tended to be subnormal. Death occurred two weeks later. At autopsy the duodenal stump had ulcerated into the head of the pancreas which throughout showed numerous focal abscesses.

Infection through the blood stream is also a possibility, but, as a rule, the pancreas seems immune to the ordinary bacteremias. It remains to be seen whether organisms with selective affinities for pancreatic tissue, such as Rosenow has demonstrated for the gall-bladder, duodenum and other tissues, will be found to play a role in pancreatitis. Tuberculous and syphilitic lesions are occasionally found, and some authors have laid great stress upon the vascular lesions as a cause of both acute and chronic pancreatitis, which if true would hark back, in the majority of cases, to microörganismal injury through the systemic circulation. It can be said, however, that clinical evidence at present does not tend to support this view.

Infection through the ducts from the duodenum or propagated from the closely associated common bile duct has received much more attention. We have seen that in acute pancreatitis it is certain that irritants introduced into the pancreas experimentally or under clinical conditions may cause most severe injury or even destruction of the organ. It is easy to assume that acting in lesser degree the same factors could give rise to slight inflammatory alteration in the nature of chronic pancreatitis. The frequent association of biliary disease with pancreatitis gives color to this idea. Désjardins, championing the ascending duct infection from the duodenum suggested that the same infection arising from the intestine and traveling up the bile and pancreatic ducts will in the former situation induce a stone-forming catarrh, but in the pancreas will cause a chronic interstitial inflammation. Up to the present time, in one form or another, the duct avenue of infection has been believed to be operative in the majority of cases of chronic pancreatitis. This, however, does not suffice to explain chronic pancreatitis as we see it under surgical conditions, when most often it is associated with an inflammatory lesion of another abdominal organ and is affected only in that region which is in close lymphatic relationship with the affected viscus and not diffusely, as would seem

to be necessary if the duct system were the seat of a catarrhal inflammation conveying infection to all parts of the pancreas. While not excluding, therefore, infection from other portals of entry we believe that the forms of pancreatitis now so often noted by the surgeon are instances of retroperitoneal infection secondary to infection of the common sites of primary abdominal localization, namely, the gall-bladder, the pyloric region, the duodenum and at times probably the appendix and other portions of the intestinal tract whose lymphatics Bartels has shown come into close relation in their retroperitoneal course with the pancreas.

That the pancreas may receive injury in other ways than by immediate bacterial invasion is possible. It is subject to a hormone and neural balance about which but little is known. Disturbances of metabolic or of nervous origin or of what Crile speaks of as the kinetic mechanism may possibly after a time be reflected in changes not only of function but also of structure. It remains for the future to develop this phase of the subject. At present no direct surgical significance attaches to the various speculations regarding them nor has operation proved beneficial in that form of the disease characterized chiefly by disturbances of the metabolic functions unless it has appeared that such disturbances were dependent directly upon disease secondary to demonstrable surgical disease or infections.

Duct obstruction, when present, is an important factor in the causation of chronic pancreatitis. Experimentally occlusion of the main pancreatic duct causes an inflammatory reaction and atrophy of the tubules. The islands of Langerhans persist longest and may be preserved apparently intact in the midst of fatty and fibrous tissue which replaces the acini. Under clinical conditions also duct obstruction is usually, if not always, associated with infection. It gives rise to interlobular pancreatitis and more or less destruction of parenchyma in accordance with the degree and duration of the obstruction and the severity of the accompanying infection. Sources of obstruction are pancreatic calculi, biliary calculi in the duodenal portion of the common duct, neoplasms, inflammatory tumefactions and cicatricial processes involving the duct. The duct of Santorini is occasionally a safety valve as it anastomoses within the gland with the duct of Wirsung in 9 out of 10 cases, and in one-tenth of all cases is even larger than the duct of Wirsung. In the majority of cases, however, it is too small or its orifice too minute to assume the function of the main excretory duct (Opie). In one-third of Opie's cases observed at postmortem some one of these forms of obstruction was present as the cause of the chronic pancreatitis. In the type of chronic pancreatitis commonly seen at operation, as previously stated, obstruction plays a smaller role.

Chronic pancreatitis is more common in the male sex. In Bohm's large statistics 65 per cent. were males. Of our cases 58 per cent., and in Opie's series two-thirds of the cases were in the male sex.

It is a disease of adult life, though it may occasionally affect children. Opie found:

Years.	Cases.
10 to 20	1
20 to 30	2
30 to 40	2
40 to 50	9
50 to 60	11
60 to 70	3
70 to 80	2

In 38 cases we found:

Years.	Cases.
Below 30	4
30 to 40	11
40 to 50	11
50 to 60	8

Naturally the age incidence is lower in an operative than in a post-mortem series. As many cases have a history of disturbance extending over a number of years it follows that the onset of the condition occurs in the majority of cases below the age of forty.

A large number of predisposing causes have been mentioned. Most firmly established is the relation to disease of the bile passages and the liver, particularly cholelithiasis. When stones are present in the common duct the liability to pancreatic disease is much increased. Cirrhosis of the liver is not uncommonly accompanied by chronic pancreatitis and in hemochromatosis it is always involved. Duodenal and pyloric disease not infrequently affects the pancreas. Other factors are duct obstruction, as already mentioned, alcoholism, lues, tuberculosis, especially the visceral form as described by Gilbert and other French writers, and trauma.

Symptoms and Diagnosis.— Chronic pancreatitis is not often observed as an isolated lesion. No analysis of a pure series of such cases is available. Ordinarily the symptoms presented during life by the subjects of pancreatitis show a large admixture of symptoms due to associated disease of other organs, usually the biliary tract. Cammidge[1] has classified on clinical grounds four groups: (1) a dyspeptic type, in which the disease is due to a morbid condition of the intestines and the symptoms are mainly referred to the digestive organs; (2) a cholelithic type, most commonly associated with the presence of gall-stones in the common bile duct, in which there is usually, but by no means necessarily, chronic jaundice, and the predominant symptoms are referred to the biliary system; (3) a miscellaneous group where the pancreatitis is secondary to malignant disease or is the result of disease of the circulatory system, etc.; and (4) a diabetic group, where there is more or less glycosuria and into which the members of the preceding groups are apt to merge in the course of time. Much confusion exists owing to the lack of any symptom which is reasonably pathognomonic of chronic pancreatitis. Cammidge regards the reaction which bears

[1] Lancet, 1911, ii, 1495.

his name as practically conclusive, but other observers have been unable to subscribe to his opinion of its value. The findings at operation are also extremely difficult to interpret, depending as they do upon the operator's opinion of the size and consistency of the gland which varies in its conformation and is always very firm and often nodular under normal circumstances. Körte admits that sections which he removed at operation from the head of a pancreas considered by him to be diseased, showed no pathological lesions when examined later by Benda. On the other hand a case is authentically reported from which a portion of pancreatic tissue was removed for microscopical diagnosis which was considered normal by the pathologist. Death following soon, the pancreas was found to be the seat of multiple abscesses. Apparently lesions may be sharply localized in the pancreas and tissue but a short distance away may show no microscopical abnormalities. Still alterations do exist which are unquestionably abnormal and inflammatory in character and will no doubt be recognized after a sufficient degree of experience with the normal gland has accumulated. These factors partly account for the extraordinary difference in frequency with which various operators have recognized the existence of pancreatitis. Thus Mayo, in 1908, reported that in 2200 operations upon the gall-bladder and biliary passages the pancreas was also diseased in 141 instances (6.1 per cent.). Robson, in much the same type of cases, found evidence of pancreatic disease in approximately 65 per cent. Much depends upon the attention devoted to the pancreas during upper abdominal sections. Thus Kehr before 1909 found pancreatitis associated with biliary disease in 10 per cent., but since then in 30 per cent. of the cases. We have found presumptive evidence of pancreatitis in approximately 35 per cent. of operations upon the biliary tract.

It is probable that the simple dyspeptic manifestations of the disease are more frequent than is realized. In all operative statistics the frequency of the more striking and disagreeable symptoms such as pain, vomiting and jaundice is magnified since it requires severe symptoms, as a rule, to bring cases to operation.

Loss of weight is a fairly constant symptom. It may be so marked as to excite suspicion of malignant disease, and particularly when coupled with persistent jaundice the simulation of carcinoma of the head of the pancreas may be complete. Strength is not usually lost in proportion to the diminution in weight. The secondary anemia which accompanies well-marked pancreatitis is usually slight and cachexia is lacking in all but the far advanced cases. Often the general well-being suffers but little and at times, especially when pancreatitis is coupled with biliary catarrh, there may be a history of recent rapid gain in weight which is not uncommon in the latter condition.

There is nothing characteristic of the type of indigestion which accompanies pancreatitis. Statistical studies show, however, that vomiting is a rather more common and prominent feature than in other diseases which are likely to be confounded with pancreatitis. Loss of appetite is usually not extreme, and seldom is disgust expressed

for particular articles of diet. Eructations, flatulence and nausea occur in many instances but usually without any definite relation to the taking of food or of special foods, though some authors have stated that the carbohydrates are not so well borne as other classes of food. Disturbances of the functions of the bowel are common. Diarrhea with the passage of stools that are pale, bulky, offensive and at times greasy is the classical and typical feature of advanced cases with pronounced pancreatic insufficiency. Such cases are rare and usually denote a condition that is no longer remediable. More often constipation is found, though at times diarrhea may alternate with costiveness. Some form of distress is commonly complained of. This varies from mere discomfort, a feeling of tightness or distention in the upper abdomen to actual severe pain in paroxysmal attacks which come on at irregular intervals. The pain may be colicky or sharp and lancinating. Colicky pain is more apt to be present when the gall-bladder is diseased and probably is to be attributed to that organ more often than to the pancreas itself. Painful sensations are felt, as a rule, in the epigastrium but also frequently in the right hypochondrium. Less commonly this pain is felt in the left hypochondrium and occasionally in the lumbar region or back. Radiations of pain may occur to the right shoulder, the back and left shoulder, or to the lower abdomen respectively in the order of frequency.

Tenderness, we have found in our operative series, is found most often below the right costal margin, probably owing to the fact that the gall-bladder was diseased in 65 per cent. of the cases and was the most painful point on palpation. Often the epigastrium is tender and at times tenderness is present in the left hypochondrium over the body and tail of the pancreas. Désjardins has described a *pointe pancréatique* which is situated 5 to 7 cm. from the umbilicus in a line running to the apex of the right axilla. This is presumed to correspond with the outlet of the duct of Wirsung.

Jaundice is present, or a history of previous jaundice is obtained frequently in any operative series, though as a symptom of pancreatic disease *per se* it is probably of less importance than would seem to be the case. With jaundice are seen the usual accompaniments of obstruction to the flow of bile, namely, clay-colored stools and the appearance of bile in the blood serum and in the urine. Cammidge has pointed out that the obstruction of pancreatitis is rarely complete, so that a small amount of bile reaches the intestine and can be demonstrated as stercobilin in the feces. The presence of stools which appear acholic owing to the excess of fat and fatty acids, coupled with chemical evidence of bile in the intestinal tract indicates incomplete obstruction of the common bile duct and is suggestive of pancreatic disease. The manner in which pancreatitis produces jaundice is still a subject of controversy. While it is true that the common bile duct in two-thirds of all cases is completely surrounded by pancreatic tissue for a part of its course behind the duodenum, it is also true that this enveloping tissue in most cases involves but a very small segment of the duct, and instances are few indeed in which actual obstruction of the duct by

swelling of this portion of the gland has been demonstrated. Undoubted cases have been observed, however, by Körte, Robson and a few others. Another experience which has happened to many surgeons is to meet with an enlarged and sclerotic pancreas in a case of chronic jaundice and to drain the gall-bladder either externally or into the intestine by means of an anastomosis under the belief that the process was neoplastic, only to find the condition clear up and the subsequent course demonstrate that it was inflammatory and not malignant. It must be granted, therefore, that the inflamed pancreas can and does in a percentage of cases obstruct the common bile duct by direct pressure. Still it is probable that in the majority of cases of jaundice with pancreatitis this symptom is due to the gall-stones, which are such frequent complications, or to cholangitis and pericholangitis. While the chronic inflammations of the pancreas are not likely in themselves by mechanical means to obstruct the common bile duct, it is nevertheless true that in suspecting pancreatitis in jaundiced states one is likely to be correct since pancreatitis is, as we have seen, a frequent complication of common duct disease. Robson has stated that pigmentation of the skin is a characteristic of chronic pancreatitis.

An idea of the relative frequency of these symptoms can be obtained in the following analysis of 60 cases of pancreatitis, half of which were accompanied by gallstones. The remainder showed no stones, though about one-third of this group also gave evidence of gall-bladder inflammation.

ANALYSIS OF SIXTY CASES OF CHRONIC PANCREATITIS OPERATED UPON IN THE LANKENAU HOSPITAL OF PHILADELPHIA.

	Thirty cases complicated by stones.	Thirty cases uncomplicated.
Males	7	17
Females	23	13
Acute severe pain	17	17
Jaundice	21	10
Vomiting	16	17
Belching	12	9
Previous indigestion	9	14
Recurrent attacks	29	21
Indigestion between attacks	8	9
Colicky pain	8	9
Seat of pain:		
Epigastrium	20	15
Right costal margin	16	12
Left costal margin	3	1
General abdominal	..	1
Lumbar	1	2
Referred pain:		
Right shoulder	12	8
Left shoulder	4	2
Back	14	8
Tenderness:		
Right costal margin	24	18
Left costal margin	3	4
Epigastrium	10	11
Gastric contents, free HCl:		
Normal	8	2
Subnormal	8	13
Above normal	1	1

The pancreas can be palpated only in exceptional instances. The tension of the recti and the interposition of the stomach, colon or liver, as a rule, prevent detection of even considerable enlargement. Occasionally, it is possible to feel the organ in individuals with very lax and thin abdominal walls, and at times it can be felt under anesthesia, when it has not been palpable before. It should be noted that the pancreas possesses a fair range of mobility in its bed of loose areolar tissue and is not, as commonly stated, fixed in position. It does not, however, move with respiration. In jaundiced states or in coincident hepatic disease the liver may extend downward over the region of the pancreas. The gall-bladder is not ordinarily palpable. Obstruction of the common duct due to pancreatitis is only in the most extreme and rare cases sufficiently complete and permanent to cause palpable distention of the gall-bladder. Another feature which militates against this condition is the frequently associated cholecystic disease which renders the gall-bladder firm and devoid of elasticity.

Early pancreatitis rarely gives any recognizable symptoms of functional disturbance. While this is regrettable from the standpoint of diagnosis, it proves the great reserve powers of the gland and is fortunate for the individual affected. For a summary of the methods employed to detect functional abnormalities the reader is referred to p. 434. Thus far these tests occupy a very subordinate position in diagnosis, and are not to be compared with the history, physical signs and clinical deductions based on the known characteristics of the disease. At times, however, they are suggestive or at least confirmatory. Most important is the constant or intermittent presence of sugar in the urine. We have found glycosuria in 7 per cent. of our operative cases. Probably repeated observations carried out over a long period of time and particularly during exacerbations of the disease would give greater importance to this symptom. We have observed a number of cases that during attacks showed glycosuria which cleared up after operation.

The pancreatic reaction of Cammidge upon the urine, though strongly championed by its originator and heartily commended by such excellent observers as Robson and Moynihan, we must reluctantly admit has not been of service to us, and in this conclusion most surgeons agree. Cammidge mentions the presence of large numbers of calcium oxalate crystals in the urine as tending to confirm a diagnosis of chronic pancreatitis. An increased amount of diastase has been noted in the urine by some observers but is not constantly present.

The best evidence of absence or deficiency of pancreatic ferments in the intestine is that given by the constant presence of the typical stools of advanced pancreatitis, described above and but seldom seen. Refinements of these gross observations, consisting in microscopic examination of the constituents of the stools for faulty digestion of muscle fibers, nuclei and fat; chemical determination of the amount of neutral fats and fatty acids; estimation of ferment activity of trypsin, lipase and amylase in the stools; indirect determination of pancreatic activity

within the bowel by means of Sahli's desmoid test or the gelodurat (sic) capsule—all of which have been the subject of a large number of ingenious experiments and observations—when carried out with rigid precautions to eliminate disturbing factors and carefully criticised with reference to factors that cannot in the nature of things be eliminated—permit certain presumptions as to the condition of the pancreas. The same may be said of the more direct methods of examination of pancreatic juice obtained from the stomach after regurgitation of abdominal contents, or from the duodenum by aspiration through the duodenal tube. The net results of all this work so far, when compared with the condition of the pancreas at the autopsy *in vivo* or postmortem, show that functional tests are unreliable as a criterion of the anatomical condition or the pathological process affecting the pancreas. Further work may increase their value in diagnosis or lead to new and important discoveries, but at the present time it is a mistake to lay too much stress on the laboratory means of diagnosis in the recognition of chronic pancreatitis. It remains a diagnosis to be made from grosser observations of symptoms and signs with a reasoned conclusion from the probabilities of the case. In the majority of cases exploration alone will decide.

In differential diagnosis there are to be considered infective and calculous disease of the bile passages and liver, duodenal and gastric ulcer, general debilitated conditions with associated derangements of digestion, such as the anemias, tuberculosis, syphilis and nephritis, abdominal tuberculosis and arteriosclerosis, chronic appendicitis, tumors of the vertebræ and tumors of the duodenum, bile ducts, liver, lymph glands and of the pancreas itself.

General disease can be ruled out by a thorough-going examination. Pancreatitis, however, may coexist. Other conditions must be differentiated, as a rule, by developing their essential characteristics since pancreatitis itself possesses fewer characteristic features than most other abdominal affections. Pancreatitis at times, however, closely simulates the other diseases which may be confounded with it. It is most important to distinguish advanced pancreatitis from malignant disease of the head of the pancreas or of other organs in the neighborhood which may give rise to chronic jaundice. At operation it is usually easy to distinguish tumors primary in other locations but when primary in the pancreas it may be difficult or impossible at the time to differentiate carcinoma from non-malignant indurative pancreatitis. It is a mistake, therefore, to conclude that such a process is malignant and to terminate the operation with exploration.

Treatment.—The treatment of chronic pancreatitis, as a rule, is that of the disease to which it is secondary. If it depends upon general conditions, such as syphilis, the treatment naturally is medical, and in any case general hygienic measures and proper regulation of diet and of the bowels are beneficial to a degree. At times the exhibition of preparations derived from the pancreas and containing pancreatic ferments is productive of symptomatic improvement. Relative func-

tional rest is best obtained medically by the Wohlgemuth diet. It must be thoroughly understood, however, that in the vast majority of cases chronic pancreatitis depends for its origin and continuance upon the presence of some surgical disease of the abdominal viscera. It is therefore hazardous to defer operative intervention, for the anatomical alterations which eventually occur as a result of pancreatitis yield neither to curative nor to palliative measures. When by the size, appearance and consistency of the gland the surgeon has determined the existence of chronic pancreatitis, he should make a careful search for all possible atria of infection within the abdomen. The bile passages should first receive attention. If the common duct contains stones, choledochostomy is indicated with removal of the calculi and the passage of a large duct probe into the duodenum to make sure that the opening is patulous and to secure full dilatation. If the gall-bladder is diseased it should be treated according to conditions. If the pancreas is not diseased to the degree of causing common duct obstruction, the gall-bladder should be removed, as it is in many instances the primary focus of infection, and as shown by Rosenow it harbors within its walls bacteria which simple drainage may not always suffice to eradicate. If, on the other hand, jaundice is a feature of the disease, and unless clearly due to stone obstruction without any element of pancreatic pressure, it is safer to provide for permanent internal drainage of the bile by means of a cholecystoduodenostomy. If mechanical conditions do not favor this operation, an anastomosis may be made with the stomach (Kehr), or with the jejunum brought up through the gastrocolic omentum (Ochsner) or with the intestine lower down. Naturally the surgeon will select a point for anastomosis which most nearly approaches the normal point of discharge of the bile. The gall-bladder may be in such condition that it is unsafe for anastomosis. In that case the surgeon may choose between stitching it to the abdominal wall to provide for long-continued drainage or he may remove it and trust to drainage of the common duct by means of a T-tube which will remain in position as long as desired. In one case referred to us by Dr. Riesman the patient, after three operations upon the common duct for cicatricial stenosis and pancreatitis has refused to part with the T-tube for fear of recurrence and has now worn it for nearly two years with practically no inconvenience and but little discharge.

Drainage for the cure of pancreatic disease should be maintained for a longer period of time than when operation is done merely for cholelithiasis. Drainage in this condition acts in two ways: It relieves infection of the biliary tract and gives the pancreas an opportunity to throw off the inflammation communicated to it from this source. Secondly, in case the pancreatic and common bile ducts anastomose before discharging through the papilla of Vater, the relief of pressure within the ducts of the biliary system at the same time releases pressure within the pancreatic ducts and favors restitution of the pancreas itself. This will occur independently of stenosis of the orifice of the papilla of Vater or contraction or spasm of the sphincter (of Oddi)

which surrounds it. Assured and long-continued drainage is the keynote of success, and this must be accomplished with the means at command. Occasionally the rarer operations, such as choledochoduodenostomy or duct reconstruction must be employed. The biliary tract is the most promising avenue of approach to the pancreas in these conditions, and in cases which show no demonstrable disease of the gall-bladder or of the bile ducts, unless other primary foci from which pancreatitis can be derived are demonstrated, it will usually be wise to drain by means of a cholecystostomy in the hope that infection of the biliary tract exists unrecognized from gross appearances, or that drainage may, in the second manner mentioned, favorably influence the process in the pancreas.

Duodenal and gastric disease when present should receive their appropriate treatment. Excision of an ulcer is preferable when it can be done. Ulcers perforating subacutely into the pancreas cannot be excised with safety. They should be treated by exclusion of the pylorus and posterior gastrojejunostomy.

The appendix should always be removed. In women the pelvis should be examined and any inflammatory tissues should if possible be excised.

The experimental work of Coffey, Sweet and others shows that in animals, at least, the pancreas admits of a variety of operative maneuvers. Drainage of the organ can be effected through the tail by means of pancreato-enterostomy which can be done by amputating a portion of tissue, exposing the duct and inserting the pancreas into the lumen of the intestine which is brought up around it, in much the same manner as in an ordinary enterostomy with a tube. It is possible that such an operation may occasionally find a clinical application. Link has reported a successful pancreatostomy in a case of pancreatic lithiasis in which he brought the tail out through the anterior abdominal wall which allowed the secretion and the stones to discharge themselves externally through the opened and dilated end of the duct of Wirsung.

CYSTS OF THE PANCREAS.

The earliest lesions of the pancreas to attract attention were the cysts which form in and about that organ. The evident symptoms and striking physical signs of the larger cysts could not escape notice and for a long time they held the center of interest. Thus Oser, in Nothnagel's *Encyclopedia* in 1903, wrote that "cysts without doubt belong to the few diseases of the pancreas that can rightly claim clinical and practical importance." That they are infrequent conditions can be judged from the fact that Segré found but two pancreatic cysts in 11,500 autopsies and Hale White only three instances in 6708 autopsies. Oser was able to collect 134 cases from the literature, and since that time in the neighborhood of 100 have been added. While they are infrequent findings they are still of great importance in that they are often amenable to operative treatment with brilliant results.

Two varieties of cysts are to be distinguished, (1) the true cysts, (2) the pseudocysts.

True Cysts.—The true cysts arise within the substance of the gland and in the beginning, at least, have an epithelial lining. Later the lining cells may disappear as the result of pressure.

The pseudocysts are collections of fluid within, or more commonly, in the immediate neighborhood of, the pancreas, which have become surrounded by a capsule of inflammatory tissue.

A third variety of cysts which are not truly cysts *of* the pancreas but rather cysts *in* the pancreas are the parasitic or echinococcus cysts. These are very uncommon. The pancreas is relatively immune to echinococcus disease. Hanser,[1] in 1912, was able to collect only 28 cases. In the large series of echinococcus disease reviewed, the pancreas was affected in only about 1 per cent. of the cases.

True cysts of the pancreas may arise in several ways.

1. **Congenital Malformations.**—Garrod mentions instances of cyst formations in the fetal pancreas and Boldt reports a case of epigastric tumor which was found at operation to be a polycystic pancreas associated with polycystic disease of the left kidney. The right kidney was not explored. Such malformations are rare and present little clinical interest.

2. **Retention Cysts.**—The earliest attempts to explain the genesis of cysts laid stress upon the factor of obstruction of the main or tributary pancreatic ducts with consequent dilatation and cyst formation by secretory distention of the distal ducts and acini. Senn showed that no such simple process could be responsible for the larger cysts as found under clinical conditions. That cysts do form as a result of obstruction is known, and cases have been reported by Opie, Cruveilhier, Virchow and others in which duct obstruction by stone, tumor or the fibrous constriction of chronic pancreatitis, stood in evident causative relation to cyst formation in the pancreas. Such cysts, however, are usually multiple, small and of themselves of little clinical significance. Some exceptions exist. Thus Wolff[2] pictures and reports a case of multiple cysts of the pancreas, which was excised by Kehr. The patient was syphilitic and the pancreas was the seat of a chronic pancreatitis to which the cystic condition was doubtless to be ascribed. Occasionally true cysts of larger size are found in a pancreas which is the seat of chronic indurative pancreatitis to which the cyst formation, with reason, seems to be attributable. Körte[3] as a result of his observation inclines to this view.

3. **Cystic Neoplasms.**—Proliferation cysts or cystadenomas occur in the pancreas. Kleinschmidt,[4] in 1907, collected 21 cases. In 4 cases the growth occupied the entire gland, in 2 the middle portion was affected and in the remaining 15 the tail only was involved. Such tumors are attached by a broad base to the pancreas but are separated from the parenchyma of the pancreas by a capsule. Occasionally

[1] Beitr. z. klin. Chir., 1912, lxxvii, 360.
[2] Ibid., 1911, lxxiv, 487.
[3] Ibid., lxxiv, 512.
[4] Med.-naturwiss. Arch., 1907, i, 177.

PLATE XIV

Multiple Retention Cysts of the Pancreas. (Four-fifths Natural Size.)

Wolff. Beitr. z. Klin. Chir., lxxii, 512.

malignant change occurs with infiltration of the pancreas and surrounding structures. Speese reports a curious case[1] which after operation and drainage ten years previously again came to operation with the cystadenomatous growth extending up to and involving the abdominal wall.

Such growths consist of a multitude of cysts, of varying sizes. Their contents are clear and serous and are practically devoid of the ferments so characteristic of other types of pancreatic cysts. They usually develop slowly without history of previous trauma or inflammation and, as a rule, give rise to few symptoms unless they attain considerable size or grow with unusual rapidity. The histology bears a close resemblance to the common cystadenoma of the ovary.

Pseudocysts.—The pseudocysts of the pancreas may be divided into:

1. **Cysts by Softening.**—A hemorrhage into the substance of the gland may subsequently soften, its blood constituents may be absorbed in whole or part and the focus converted into a cyst cavity. Malignant foci also may undergo degenerative processes forming a cyst of irregular contour with grumous contents. Such formations, though they are in reality cystic in character, do not attract clinical attention as such. They are by-products of pathological processes in which the cyst formation plays a secondary part. More important are the

2. **Cysts by Self-digestion.**—The importance of activated pancreatic ferments in the pathogenesis of pancreatic disease has been discussed. Instances are not rare in which a large part of the pancreas, and at times probably, the entire pancreas undergoes rapid necrosis and gangrene as the result of a combination of injury, chemical, bacterial or traumatic, with enzymic action. The autodigestive process does not stop with the necrosis of the gland and its surrounding tissues, but proceeds actively to break down and dissolve the structures affected. Naturally, in the more severe cases the process is interrupted by the death of the patient, but in cases of less severity which are compatible with continuance of life there results a cavity containing disintegrating tissue, blood, fluid and cellular exudates and bounded by a limiting inflammatory wall. The resulting formation is dependent upon the activity of the contents as they relate to the process of exudation and absorption exercised by the surrounding tissues. It is not uncommon for such cysts to fluctuate in size in accordance with the altering balance of these processes. Such changes in volume are of some diagnostic importance. Usually there is a tendency for an increase in size but at greatly varying rates of speed in individual cases. Heiberg[2] quotes Hulke as having observed a case of forty years' duration. More commonly the development of such a cyst to a condition where it is noticeable for its size and symptoms is a matter of several weeks or several months. After a long time the contents of these pseudocysts may become relatively clear and serous. As a rule, however, when investigated they are bloody and contain more or less undissolved

[1] Ann. Surg., 1915, lxi, 759.

[2] Die Krankheiten des Pankreas, Wiesbaden, 1914, p. 141.

tissue fragments. The interior wall is ragged and may show masses of adherent necrotic tissue. This variety of cyst is the most common and important from a clinical standpoint.

3. **Exudative Cysts of the Omental Sac.**—The location of the pancreas immediately beneath the floor of the lesser peritoneal cavity frequently determines extravasation of blood and inflammatory exudates into that cavity. The foramen of Winslow may have been previously obliterated as a result of upper abdominal inflammation, to which indeed the pancreatitis may be a sequel or concomitant. Or closure of the opening may rapidly take place as a result of the violent and widespread inflammation engendered by acute pancreatitis. As a rule, such collections are infected or become invaded secondarily by microörganisms and appear more truly as an abscess than as a cyst, but occasionally bacterial activity is low or absent and the collection may exist for a considerable time without producing serious systemic symptoms.

Size and Situation.—Occasionally pancreatic cysts are of great size. Parke's case, mentioned by Ochsner, contained 14 liters of fluid, and Trendelenburg met with one which held about 20 liters. Cases of such great size, always rare, are now, owing to the prevalence of surgical treatment, practically unknown. Ordinarily, they vary from a size that is just palpable to that of a child's head, and contain one to three liters of fluid. Their location shows wide variations from the epigastric or left epigastric position, which may be described as typical. Both the true cysts or pseudocysts may arise from the head, the body or the tail, or they may involve the entire organ. The point of presentation is influenced not only by the site of origin but by anatomical considerations which direct its course in accordance with the law of expansion along the line of least resistance. The most frequent direction of growth is directly forward from its point of origin beneath the floor of the lesser peritoneal cavity, causing it to protrude into that sac. Here it may carry the stomach directly before it, and in inflated or distended conditions of the stomach the cyst can be palpated only indefinitely through that viscus, and percussion may give the tympanitic note of an air-containing cavity. As the cyst enlarges, however, it tends to push the stomach aside and present against the abdominal wall covered only by the gastrocolic omentum. The colon also is pushed downward and in extreme cases may be dislocated into the pelvis. The anatomical relations can be best appreciated by a study of Zuckerkandl's schematic representations.

In a second form the enlarging cyst pushes the stomach downward and presents against the anterior abdominal wall covered by the gastrohepatic omentum. This is most apt to occur in conditions of gastroptosis. Körte, in an examination of 30 cadavers, found a portion of the pancreas exposed above the lesser curvature of the stomach covered only by the gastrohepatic omentum in 3 cases (10 per cent.). In such cases gastric tympany will be found below the area of dulness due to the cyst, and if the tumor be well toward the left the physical findings can be readily mistaken for those due to an enlarged kidney, or if it be

situated to the right of the midline it can be confused with a distended gall-bladder, both of which errors we find recorded in the literature.

A third combination is found in cases where the cyst lies between the layers of the transverse mesocolon. If it presses directly forward dividing symmetrically the upper and lower layers of the mesocolon, it carries the transverse colon before it stretched transversely across its surface. More commonly it deviates upward or downward, in the first instance presenting, as in the second variety, through the transverse mesocolon and in the second instance, bulging downward into the general peritoneal cavity with both stomach and colon lying above it.

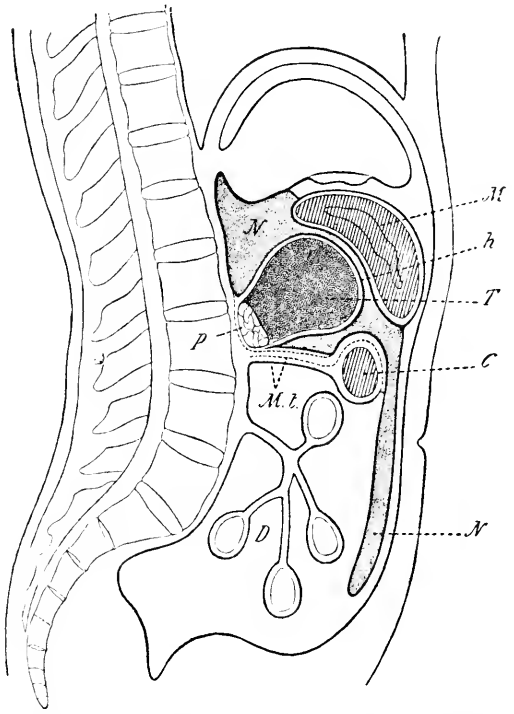


FIG. 231.—Tumor of the ventral surface of the pancreas projecting into the bursa. The stomach lies in front of, the colon below, the tumor. *M*, stomach; *C*, transverse colon; *P*, pancreas; *D*, coils of intestine; *N*, omental bursa; *M.t.* the two layers of the transverse mesocolon; *h*, posterior layer of the great omentum; *T*, tumor.

The pseudocysts, particularly when accompanied by more marked destructive effects of enzyme and bacterial activity, follow less regularly the above methods of expansion. Retroperitoneal collections of this character tend to gravitate toward the left loin, burrowing through the perinephric fat below the pole of the left kidney and presenting upon the parietes below the border of the last rib. Extravasation cysts in the lesser peritoneal cavity also frequently impinge upon the abdominal wall in this location. Less commonly a gravitation abscess

arising from the head of the pancreas may make its way in a similar manner into the right loin. Naturally, the relations of the movable viscera vary much in detail but these types are serviceable in that they are at times of great assistance in preoperative diagnosis.

Symptoms and Diagnosis.— Körte divides pancreatic cysts on clinical and etiological grounds into three main groups: (1) those which follow trauma, (2) those which follow inflammatory processes, (3) those which gradually develop as a tumor without evident predisposing cause. Of 121 cases collected by him 33 belonged to the first group, 33 to the second, and 51 to the third group.

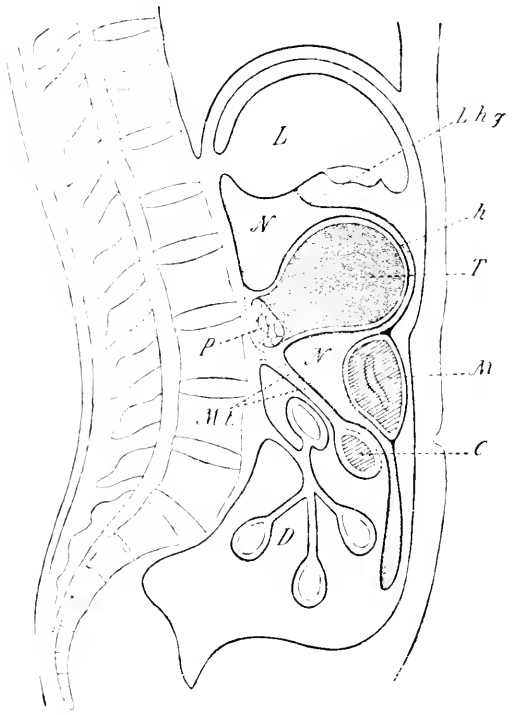


FIG. 232.—Tumor projecting into the omental bursa, pushing the lesser omentum forward. Stomach and colon lie below the tumor. *L*, liver; *M*, stomach; *C*, transverse colon; *P*, pancreas; *D*, coils of intestine; *N*, omental bursa; *L.hg*, ligamentum hepatico-gastricum (lesser omentum); *M.t*, the two layers of the transverse mesocolon; *h*, posterior layer of the great omentum; *T*, tumor.

In over one-half of the cases the anamnesis may give a direct clue to the nature of the tumor. A common history is that of a wagon passing over the body, a crush between cars or a blow in the epigastrium. The abdominal wall may be contused but is usually not lacerated. There may or may not be symptoms of internal hemorrhage, but the immediate shock is great and severe epigastric pain is complained of which is likely to subside and reappear in paroxysms at varying

intervals and is often associated with vomiting. Improvement occurs but the abdomen remains sensitive and troublesome. After a time, which may be but a matter of a few days or weeks, but more commonly is several months or years (Oser says most often one to three years), a lump is found in the abdomen. The patient in not a few cases first detects the lump and calls attention to it.

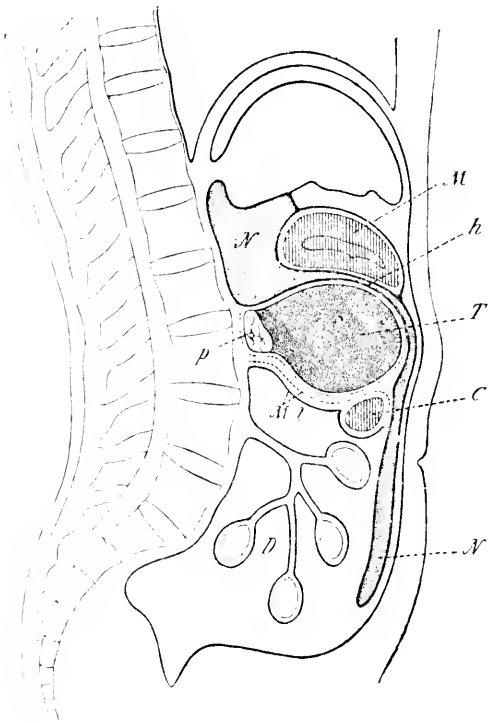


FIG. 233.—Tumor symmetrically developed in all directions, projecting between the posterior layer of the great omentum and transverse mesocolon. Stomach above, colon below, the tumor. *M*, stomach; *C*, transverse colon; *P*, pancreas; *D*, coils of intestine; *N*, omental bursa; *M.t*, the two layers of the transverse mesocolon; *h*, posterior layer of the great omentum; *T*, tumor. The anterior layer of the great omentum, which is pushed forward between the stomach and colon, corresponds to the gastrocolic ligament.

In a second large group of cases the patient gives a history of a sudden severe upper abdominal seizure which he may have been told was obstruction of the bowels, gall-stones or gastritis. A number of such attacks, varying in severity, may be related, or the history may be that of a series of dyspeptic troubles accompanied by pain, often by nausea and vomiting occurring at irregular intervals and without any apparent predisposing cause. The nutritional state has usually suffered to some extent but cachexia is absent in all but the more advanced cases. A history of syphilis is obtained in a small percentage of cases and in the absence of a definitely palpable mass may cause the pain to be ascribed to gastric crises.

In the third group no history of injury or evidence of previous abdominal disease can be elicited.

Pain is an almost invariable feature of pancreatic cysts. In cysts of inflammatory origin this may be due partly to the frequent involvement of other upper abdominal structures in associated inflammatory processes. An admixture of gall-bladder symptoms is not uncommon. Cysts secondary to chronic pancreatitis give a history of pain owing to their dependence upon a condition which in itself is usually painful.

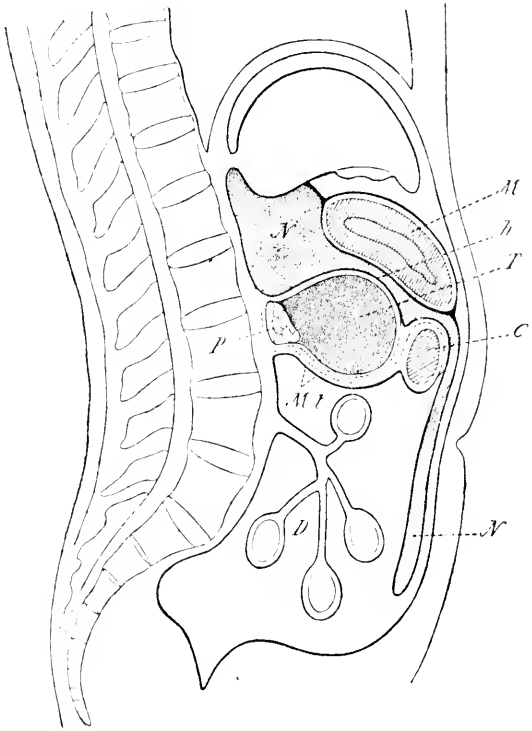


FIG. 234.—Tumor of the same region, developed on one side, growth largely toward the omental bursa. Stomach lies above the tumor, and colon in front of the lower portion. *M*, stomach; *C*, transverse colon; *P*, pancreas; *D*, coils of intestine; *N*, omental bursa; *M.t*, the two layers of the transverse mesocolon; *h*, posterior layer of the great omentum; *T*, tumor.

Quite aside from these causes of pain, however, is the pain due to the cyst itself. Its location in immediate relationship to great nerve centers and trunks and its proximity to important viscera which are often much compressed, displaced and involved in adhesions are sufficient to cause considerable disturbance. Pain may often be felt before the cystic condition of the pancreas becomes palpable. It is located most commonly in the epigastrium at the site of the pancreas. It may be felt in the back or in the right or left side. Occasionally it is reflected

downward into the iliac fossa. It is variable in degree and non-characteristic in kind.

The stomach, true to its usual function as spokesman for all abdominal disorders, commonly shows signs of disturbance. Loss of appetite, pyrosis, nausea, vomiting, cardialgia and other sensations of discomfort or distress are frequent. Symptoms referable to the bowel are common. Formerly diarrhea was thought to be characteristic, but in many cases constipation is quite as marked a feature, or diarrhea and

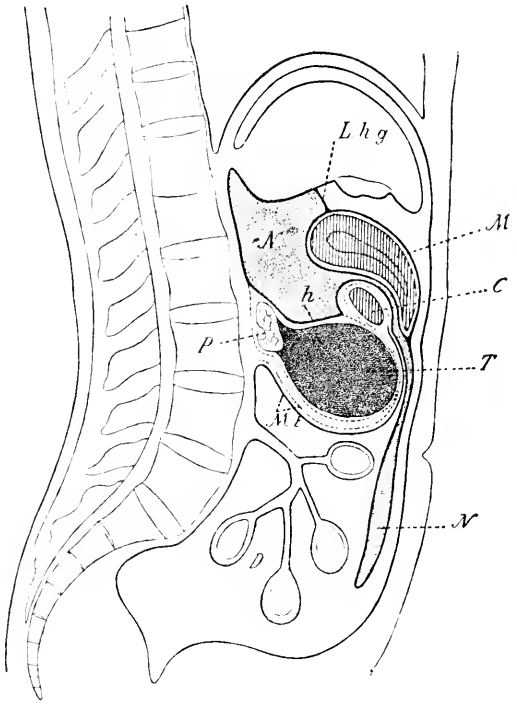


FIG. 235.—Tumor of the same region developed on one side, growth largely downward toward the mid-abdomen. Tumor lies below the colon and stomach. *M*, stomach; *C*, transverse colon; *P*, pancreas; *D*, coils of intestine; *N*, omental bursa; *L.hg*, gastro-hepatic ligament; *M.l*, the two layers of the transverse mesocolon; *h*, posterior layer of the great omentum; *T*, tumor.

constipation may alternate. When the pancreas is extensively diseased or largely thrown out of function the stools take on the characters associated with pancreatic insufficiency. Very occasionally the cyst may rupture into the bowel and cause a profuse liquid evacuation simultaneously with the disappearance of the cyst. Or, as in Pepper's case, the rupture may be into the stomach or upper intestine, and the contents be vomited.

Ptyalism has been observed in connection with pancreatic cysts, but is an uncommon and unimportant symptom.

A great variety of pressure effects may occur. Jaundice, due to

pressure on the common bile duct, edema of the extremities and ascites due to pressure on venous channels, renal colic, as a result of compression of the ureters, as well as other phenomena have been noted in individual instances. These are chance occurrences and but seldom possess diagnostic value.

Loss of weight due to disturbance of pancreatic function as well as of the alimentary tract is common.

Fluctuation in size of the tumor, a general characteristic of cysts, has been observed many times.

Glycosuria was noted by Körte 9 times in 33 traumatic cysts, but collective reports of all varieties of cysts do not show such a high percentage of this symptom. When present it is strongly confirmatory of the diagnosis.

Cammidge acknowledges that his reaction is of no assistance in the diagnosis of this condition and the functional tests in general are of less use than in certain other diseases. At times cystic disease of the pancreas is the outcome of a condition which has produced marked diffuse disease of the organ, in which case the signs of pancreatic insufficiency may be pronounced.

Pancreatic tumors do not move with respiration. If inflammatory they cannot be moved by the hand. When they develop without inflammation they may possess the usual mobility of the pancreas which, contrary to the general idea, is quite freely movable within a short radius.

The *x*-ray has been employed in diagnosis and is of some assistance in showing the relation of the stomach and intestines to the mass, but no direct evidence as to its nature is obtainable by this means.

Exploratory puncture, formerly much used, has led to some very disastrous results due to infection of the peritoneal cavity. It must be emphatically condemned. The only field for puncture which Körte allows is in the cysts which present in the loin when the mass can be reached extraperitoneally, and even in these cases it should be done only when it is possible to proceed at once with the operation.

The investigation of the character of the cyst contents is of considerable importance in determining the nature of the condition. It is not always possible by operation to establish the fact that such cysts are in reality of pancreatic origin. Grossly the contents vary from clear serous fluid to bloody, purulent, grumous or necrotic material.

The demonstration of the characteristic ferments of the pancreas is sufficient to make the diagnosis. The presence of small amounts of a lipase or amylase is not necessarily indicative of pancreatic origin. Trypsin, however, is distinctive. It may exist only in the proferment form, and must be activated before it will produce its digestive effects. As pancreatic juice is ordinarily collected from the sinuses remaining after drainage of the cyst, the trypsin is activated by the admixture of tissue juices and bacteria. Clinically, the ferment activity of the secretion can be only too well observed in its corrosive effects upon the skin or other tissues with which it comes into prolonged contact.

Slight febrile attacks are common, but in general the temperature is normal as is also the pulse. The leukocytes range from a normal number in the majority of instances to a moderately high leukocytosis during attacks or when infective processes are present.

The diagnosis of pancreatic cyst can usually be made from a few salient features after exclusion of conditions with which it may be confused. The most characteristic positive features are a history indicative of previous pancreatic injury or disease, the location in the neighborhood of the pancreas, the gradual and symmetrical growth and occasional fluctuations in size, the pain, digestive disturbances and wasting without cachexia, and the relations of the tumor to the stomach and intestines. Glycosuria and evidence of faulty pancreatic digestion, if present, are of strong confirmatory value, but are found in only a minority of cases.

The conditions with which it may be confounded are:

1. Aneurysm of the abdominal aorta, from which it may be distinguished by the absence of transmitted pulsation when the patient is placed in the knee-chest position.

2. Abscess of the abdominal wall, the superficial position of which can be made out by careful examination.

3. Echinococcus cyst of the liver. This will be located in front of and above the stomach. A pancreatic cyst may in rare instances present above the stomach but it can never lie in front of that organ. The hydatid thrill may be present and in a percentage of cases a complement-fixation reaction using hydatid fluid as antigen will be positive. Less frequently echinococcus cysts occur in this region in connection with other organs. They cannot always be differentiated. The history may be significant.

4. Tumors of the liver are usually clearly continuous with liver dulness and occupy the same position as described above with relation to the stomach. They are movable with respiration which is contrary to the usual finding in the case of a pancreatic cyst.

5. Enlarged gall-bladder is distinguished by its superficial location, its mobility with respiration, a lateral motion usually being demonstrated, as well as the more marked upward and downward excursions.

6. Retroperitoneal hygroma or lipoma cannot be certainly distinguished, but is rare.

7. Cyst of the round ligament, a rare condition, is more movable laterally and moves with the abdominal wall.

8. Splenic cysts are never covered by stomach or bowel.

9. Cysts of the mesentery are lower in position and possess a much greater range of mobility.

10. Pancreatic abscesses give a history of stormy onset with toxemia and evidences of an inflammatory process.

11. Collections in the lesser peritoneal cavity are often secondary to acute pancreatitis and give the history and systemic symptoms of that disease. When due to perforated gastric ulcer, the type of indigestion preceding the attack is of assistance and the pronounced signs of an inflammatory process differ materially from the effects of a cyst.

12. Tumors and cysts of the kidney and adrenal bodies by bimanual palpation are found to lie chiefly in the region of the loin. They move with respiratory excursions and in the case of the kidney the composition of the urine and a combination of *x*-ray and cystoscopic examination will make the condition clear.

13. Tumors of the vertebral column can be ruled out by their consistency, their absolute fixity, and by *x*-ray findings.

14. Retroperitoneal tuberculous collections or glandular masses are infrequent in adults.

15. Tumors and inflammatory masses of the peritoneum or omentum are more superficial and usually differ in contour and consistency.

In the individual cases many other differentiating points will suggest themselves, but after all due care has been used it must still be said that a considerable percentage of cases will wait for diagnosis by exploratory operation. No pathognomonic symptoms or set of symptoms exists, but to the surgical mind the symptoms and signs will always point to the advisability of operation.

Treatment.—Pancreatic cyst is purely a surgical disease and is to be attacked directly and boldly by open operation. In almost all cases a transperitoneal operation must be done to reach the cyst. Occasionally cysts may present in the loin when they can be attacked retroperitoneally. This concerns only the pseudocysts. We find no mention of true cyst development in this manner. Rarely do pancreatic cysts, protected as they are by overlying viscera and omenta, contract sufficient adhesions to the abdominal wall against which they present to justify the attempt at direct incision through parietes into the cyst. Such a condition, if present, can be determined only by careful exploration. The incision should be made over the most prominent portion of the cyst and prolonged sufficiently to secure ample exposure and control. If in doubt as to the nature of the swelling, at this point an exploratory needle may be introduced. It may be necessary first to divide the overlying omentum or mesocolon to secure exposure. If the mesocolon is opened especial care must be taken not to injure the middle colic artery, as this is very likely to cause gangrene of the transverse colon, an accident which has happened in operating for pancreatic cyst. If the artery has been unwittingly or intentionally sacrificed, it is best to resect the bloodless portion and make the necessary anastomosis. It is highly undesirable to be obliged to do this, and in general if at all possible one should avoid opening a cyst through the lower layer of the transverse mesocolon since this exposes the general peritoneal cavity to contamination and increases the difficulties of drainage.

The relations of the cyst may now be explored. Before any operative procedure is attempted it is wise to wall off the surrounding intestines both for purposes of control and for protection against possible dangerous contamination by the cyst contents. Exploration and subsequent procedure will often be facilitated by draining off with a trocar and cannula a portion of the cyst contents. Only three methods of dealing

with the cyst are to be considered: (1) drainage by marsupialization, (2) excision, (3) partial excision and drainage. The method to be chosen will be indicated by conditions. As a rule, the first method is the easiest, safest and most satisfactory. It is impossible to excise the pseudocyst as its wall is made up of the structures which wall it in. But many of the true cysts also contract such intimate adhesions with essential structures that to attempt to excise them is extremely hazardous if not impossible. After completely emptying the cyst, by suction or by mopping, a view may be had of its interior. If time and the condition of the patient are pressing this step would be omitted. The opening into the cyst is now sewed to the peritoneum and transversalis fascia with a running or interlocking stitch placed close enough to prevent immediate leakage into the peritoneal cavity. The peritoneum above and below is closed and drainage of the cyst cavity instituted. If the contents are believed to be sterile and the interior of the cyst reasonably free from necrotic masses of tissue, a large tube will be sufficient. Closure under these circumstances may take place with remarkable rapidity, healing being complete in two to three weeks. If any doubt exists as to the liability to pocketing or retention of tissue that may later be discharged, it is best to use tampons of gauze as well as one or more tubes. If gauze is used it should not be removed too soon or too forcibly as it may cause troublesome bleeding or dislodge an embolus. The best rule is to remove the gauze gradually as it is cast off by the tissues as a slough. At the same time care should be taken that the gauze should not act as a plug to dam back retained secretions. This may be prevented by loosening the gauze at the outlet before the attempt is made to extract it from the depths.

If excision is to be attempted it should be done only after a careful survey of its possibilities. Pancreatic cysts are almost never pedunculated. Occasionally a cyst of the tail may be capable of removal, the tail itself acting as a pedicle. Mayo[1] resected the distal half of the pancreas for a cystic tumor, encountering bleeding that could not be checked with ligature or sutures. He left clamps *in situ*, and packed with gauze. The patient recovered. In case of doubt excision should not be attempted. If the pancreas is subjected to operative manipulations, these should be carried out with all due gentleness, bearing in mind the possibilities of hemorrhage and ferment activation after simple trauma. Drainage should always be employed, for a short period at least, when the gland is injured. In one variety of cyst, namely, the cystadenoma or proliferation cyst, excision is indicated if it can be carried out. Simple drainage does not cure these cysts because they are multilocular and cannot be completely drained and, because of the activity of the epithelial lining, it is difficult to secure an obliteration of the secreting surface. Cystadenoma if densely adherent to important structures should be considered inoperable or the larger cysts drained for relief of size and pressure symptoms. It is quite

[1] Ann. Surg., 1913, lviii, 145.

permissible, however, to assume some risk in the hope of making a complete excision. The pancreas as a whole should never be removed.

Partial excision and drainage is a compromise operation which enjoys the advantages neither of excision nor of marsupialization. It increases the difficulty of safe and thorough drainage of the contents of the sac and should rarely, if ever, be employed.

In a number of cases drainage has been done in two stages, first attaching the cyst to the abdominal wall and later, after the peritoneal cavity has been walled off, opening the sac to provide drainage. It is an inferior measure in that it does not give immediate relief during the most trying postoperative period, and practically the method of protecting the peritoneum by sewing the edge of the marsupialized pouch to the peritoneum has been found effective. In individual cases there may be good reason for preferring the two-stage operation.

The sinuses which exist after drainage of a pancreatic cyst are at times very troublesome. This is due to two causes: (1) obstruction to normal flow of pancreatic secretion into the duodenum causing it to seek the path of less resistance through the artificial opening, and (2) because of the irritating qualities of the pancreatic ferments which erode the sinus walls and hinder or prevent granulation and closure. In many cases the drainage of the cyst appears to act favorably upon the remaining pancreas, so that after a time the normal channels resume their functions, less and less secretion is directed into the sinus which at the same time by its attempt at closure encourages the secretion to take its normal course and gradually the discharge ceases and the sinus walls unite. In case of persistent fistula, Wohlgemuth proposes that the patient be placed upon a strict antidiabetic diet with large doses of sodium bicarbonate after meals, on the theory that in this way the pancreas would be less stimulated to secrete and the cyst cavity and sinus walls be given a better opportunity to granulate and close. A number of surgeons have reported excellent results of this treatment, though not all experiments have been so favorable. Körte has pointed out that its theoretical basis does not accord with the classical work of Pawlow on the secretion of the pancreas, since he found that carbohydrates were more stimulating to the secretory output than fat. It is advisable, in troublesome cases to give the method a trial since no form of local treatment has any influence in promoting healing.

It is well in dressing all cases of this kind after operation to begin at once to protect the skin wherever the secretion may come into contact with it by a heavy coating of zinc oxide ointment or vaseline as the erosions which occur are painful and after once formed are almost impossible to heal so long as the discharge exists.

PANCREATIC CALCULI.

Concretions in the pancreas are infrequent. Opie found 3 instances in 1500 autopsies and Kretz estimated that they occurred on the average once in 3000 cases. Giudeceandra encountered 2 in 122 cases.

Oser, in 1903, found 70 cases on record and since then the number recorded has increased to approximately 90.

Etiology.—But little is definitely known of the etiology of calculus formation in the pancreas. Stasis and infection are believed to be the chief factors, though Pende,[1] from his experimental investigations into the process of stone formation, came to the conclusion that infective processes were not responsible for the condition and assigned the leading role to pancreatic sclerosis induced by the circulating toxins of lues gout, alcoholism and other metabolic disorders.

Pancreatic stones are usually multiple and small. The largest is recorded by Schupmann which measured two and a half inches long and a half inch in diameter. More often they are stated to be the size of a pea or bean and vary down to almost impalpable sand which may be present in abundance, either free or incrusting the lining of the ducts. In a few cases putty-like masses have been found, but ordinarily the pancreatic stone is quite hard being composed chiefly of the carbonate and the phosphate of calcium. They are rarely facetted but may be very irregular in shape. Round, oval, branching, mulberry and spiculated stones have been described. Commonly they are white, gray or yellowish, but dark and even black stones have been found. Occasionally gall-stones have made their way into the head of the pancreas by ulceration from the common duct. Dowd reports such a case. They can be distinguished by the cholesterin and bile pigments of which they are chiefly composed, constituents which are rare or absent in pancreatic calculi.

The stones are found most often in the head but may be located in any portion of the organ. In a number of cases they were present in such numbers as to fill the ducts throughout the organ.

By far the greatest number of stones occur in the male sex (26 males and 6 females—Oser) and have been discovered most often in individuals between the ages of thirty-five and forty-five years.

Symptoms.—Kretz states that barely one-third of the subjects of pancreatic calculi show symptoms during life. As his conclusions were based on cases observed at postmortem we cannot accept the statement as entirely reliable since this method of drawing conclusions has been shown to be fallacious in many other conditions, notably cholelithiasis. It is true, however, that distinctive symptoms are lacking in many cases. Lazarus divides the symptoms into five groups: (1) essential symptoms of stone, (2) symptoms due to sequelæ, (3) functional disturbances, (4) symptoms due to effects upon other organs, (5) general symptoms.

Of symptoms due to the presence of the calculus the most important is pain. This is often severe and colicky, and usually located in the epigastrium and left hypochondrium. It tends to radiate to the back and left shoulder. During attacks vomiting often occurs and at times chills, moderate fever and sweats are indicative of accompanying infective processes. Collapse may be the result of a severe seizure.

[1] Il Policlinico, 1905, vol. xii; Sez. Med., p. 122.

When the stone also obstructs the common duct the pain may have the characteristics of gall-stone colic. In a number of cases the calculi have been found in the stool after attacks or in the interim.

The results of pancreatic lithiasis are various: chronic pancreatitis, complete atrophy of the pancreas, hemorrhagic pancreatitis and necrosis, the formation of true cysts, pseudocysts and fistulæ have all been reported. In such cases the symptoms take on the characteristics of the resulting conditions.

Disturbances of the function of the pancreas are common. Zesas,[1] in a study of 70 cases, found that glycosuria was the most frequent symptom, but concluded that it was a late manifestation. It may be slight, intermittent or may possess all the characteristics and severity of true diabetes. In extreme cases indeed the destruction of the pancreas is so complete as to amount to a pancreatectomy so far as function is concerned. Bissell[2] in one instance was unable to discover any pancreatic parenchyma by the aid of the microscope. The pancreas existed only as a distended system of ducts. v. Recklinghausen found the pancreas reduced entirely to a fatty mass without parenchyma. On the other hand, Walker[3] reported a case, observed for twenty-six years, which at autopsy showed pancreatic calculi blocking the duct and advanced atrophy of the parenchyma, yet never developed glycosuria or other evidences of disease of the pancreas. More often the late cases with extreme alterations in the pancreas show more or less pancreatic insufficiency, with steatorrhea, azotorrhea and disturbance of absorption.

Symptoms due to involvement or disturbance of function of related organs are seen most often in involvement of the biliary tract by obstruction or ascending infection which gives rise to jaundice and biliary colic. Pigmentation of the skin has been noted. In a case operated upon by Moynihan this disappeared after removal of the calculus. The stomach and duodenum may be interfered with by adhesions or by reflex influences and the bowels are disordered. Ptyalism has occasionally been observed.

General symptoms are loss of weight and of strength, anemia, in some cases a veritable cachexia, and the evidences of infection. During exacerbations, fever, chills, sweats and leukocytosis may be present. It is noteworthy that a large proportion of subjects of pancreatic stone die of tuberculosis.

Diagnosis.—Diagnosis is difficult or impossible. Of the 70 cases reported by Zesas only 7 had been diagnosed during life. It depends upon persistently recurring upper abdominal indigestion with painful exacerbations, plus pronounced symptoms of pancreatic insufficiency. If stones corresponding in character to pancreatic calculi are found in the stools, the diagnosis is a reasonable certainty. Einhorn, Glaessner and others have reported such cases. The *x*-ray may prove to be of

[1] Centralbl. f. d. Grenzgb. d. Med. u. Chir., 1903, vi, 801.
[2] Tr. Chicago Path. Soc., 1914, ix, 167.
[3] Med.-Chir. Tr., 1889, lxxii, 257.

some service though the difficulties of detecting stones as well as of ruling out confusing shadows in this location are great. Pförringer reports a case in which he detected a shadow just to the right of the midline in a case thought to be one of renal calculus. He considered it too near the midline and advised further examinations. The patient went elsewhere and was operated on for renal calculus, which was not found, but death occurred from hemorrhage. At autopsy a pancreatic calculus was present. Assmann, in a review of plates made for the purpose of an intestinal study, upon a case found at operation to have pancreatic calculi, discovered the definite shadows of a calculus which had been overlooked during the earlier examinations.

Treatment.—Treatment of pancreatic lithiasis is greatly limited by the difficulties of diagnosis both before and during operation. The firm consistency of the gland may make it impossible to feel stones even when present. Again the variations in size, situation and number of calculi make it impossible to standardize a method of procedure. Still it remains true that this condition is properly surgical, and medical treatment cannot be regarded as anything but palliative and expectant. Various regimina of medical treatment have been advised. Eichhorst in one case administered pilocarpin to stimulate the flow of secretion and reported the patient much improved. On the other hand, Glaessner and others have tried to inhibit the flow of pancreatic juice by the "Oelkur" and large amounts of alkaline fluids, likewise reporting good results. The truth seems to be that the disease is characterized by exacerbations and remissions, though naturally measures directed at the control of symptoms and the alleviation of gastric and duodenal irritation will prove beneficial.

The earliest operative case is that of Gould,[1] who opened the abdomen for symptoms of cholelithiasis. Feeling a mass behind the lesser omentum he explored, incised and removed a branching stone from the duct of Wirsung. The patient recovered, but the obstruction to the common bile duct was still evident from the fact that all the bile continued to discharge from the cholecystostomy opening made at the operation. Seven months later he again operated, located a stone in the head of the pancreas, removed it through an incision in front and was able to pass a probe into the duodenum. Unfortunately, the patient succumbed to infection on the twelfth day.

Moynihan[2] relates a singularly successful case in which he diagnosed the condition and was able to extract the calculus from the papilla of Vater through the duodenum. Dalziel is said by Robson and Cammidge to have had a similar successful case, and the same authors mention another instance in which recovery followed the removal of four stones from the pancreas. One stone was removed from the duct of Santorini and one from the duct of Wirsung by direct incision into the gland and two were extracted from the papilla of Vater by forceps.

Stoeblin and Roeber[3] incised the pancreas and successfully removed

[1] Lancet, 1898, ii, 1632.
[2] Lancet, 1902, ii, 355.
[3] New York Med. Jour., 1905, lxxxii, 904.

several stones from the duct of Wirsung. Lisanti is credited by Körte[1] with having removed a stone from the pancreas. Ruth[2] operated for gall-stones and found the pancreas filled with concretions, the largest being over two inches in length and weighing 280 gms. Recovery followed removal of the stones by direct incision with drainage of the pancreas. Link[3] in a somewhat similar case performed the unusual operation of pancreatostomy by mobolizing the tail of the pancreas and bringing it through the incision in the abdominal wall. Drainage of pancreatic secretion and discharge of numerous concretions followed. On a number of occasions the drainage of a pancreatic cyst or abscess has permitted the discharge of calculi whose presence had not been suspected. From the work already done it is apparent that in fortunate instances the stone may be removed through the papilla of Vater and this incised or dilated if necessary to further drainage and the discharge of such concretions as may remain. Furthermore, it is shown that under proper conditions the pancreas may be incised and the ducts opened for the extraction of calculi. The procedure cannot be said to be without risk, but the precise mortality cannot be estimated at present. Freedmann courageously reported a case operated upon by Peck with a diagnosis of pancreatic stone in which exploration of the pancreas by incision of the gland and opening the duodenum was followed by death. The symptoms were typical. No stone was found either at operation or at autopsy. Doubtless it is unwise to attempt to explore the entire duct by incision, but a suspected focus may be opened with every prospect of recovery and a probe will determine the patulous condition of the duct. It is easy to make false passages in the pancreas with a small probe and if the duct is not found distended it may be hard to find and difficult to explore. Great gentleness and clean dissection are advisable particularly in the light of our knowledge of trauma and infection as causes of hemorrhagic pancreatitis. Mayo has shown that bleeding from the cut surfaces of the pancreas may be safely controlled by oversewing the bleeding surfaces with catgut on a curved needle.

The safest rule is to drain every case of incision into the pancreas, particularly if the duct has been reached. A combination of gauze and tube may be required, but in cases of minor injury a small cigarette drain may be sufficient. To prevent the drain from being displaced a simple stitch of fine plain catgut may be used to fasten it temporarily to the area which it is desired to drain.

It is probable that with greater regard to the condition of the pancreas both before and during operation, more cases will be discovered and additions made to our knowledge of the safest and most salutary method of dealing with pancreatic calculi.

[1] Entwick u. Fortschr. d. Chir., 1909, p. 310.
[2] Colorado Med., 1907, iv, 421.
[3] Ann. Surg., 1911, liii, 768.

CHRONIC GRANULOMAS OF THE PANCREAS.

Tuberculosis.—The pancreas is not immune to tuberculosis, but rarely does it play any considerable part in simple pancreatic disease unless it be true, as maintained by some, that the toxemia of tuberculosis is responsible for sclerotic changes leading to functional insufficiency. Chabrol[1] distinguishes the following varieties: (1) sclerosing pancreatitis due to toxemia and infection without specific lesions; (2) the caseous form; (3) a granuloma form in which tuberculous granulation tissue forms masses of small or large size; (4) à forme infiltrée characterized by diffuse and marked round-cell formation likely to be mistaken for a sarcoma (pseudoneoplasique). The entire pancreas may be imbedded in a mass of tuberculous and sclerotic tissue and may contain tuberculous glandular nodules in its substance. In one instance these were successfully removed from the tail of the organ by operation. Guinaud[2] reported one case in which tuberculous peripancreatic sclerosis involved the common bile duct and caused fatal jaundice. In general, tuberculosis of the pancreas possesses little surgical significance.

Muroya[3] reported a curious case operated upon for indurative pancreatitis which appeared at operation to be the seat of miliary tuberculosis. A small section removed for microscopical study showed areas resembling tubercles but due to a diffuse deposit of eggs of the ascaris lumbricoides. The patient recovered and three months later was much improved.

Syphilis.—Syphilis affects the pancreas either by a diffuse sclerosing process or by the formation of gummas, which are rare. In hereditary syphilis developmental anomalies can be seen histologically and at times may produce gross alterations. Dupérire[4] reports a multiple cystic condition of the tail of the pancreas in a child four months old who suffered from hereditary syphilis. A Wassermann reaction is part of a proper study of all cases of chronic pancreatic disease and specific treatment should be employed in positive or doubtful cases. By this means such cases should be eliminated before operation.

TUMORS OF THE PANCREAS.

Benign Tumors.—The most common benign tumor of the pancreas is the cystadenoma. This has been discussed under the heading of cysts. Non-malignant solid tumors of the pancreas are exceedingly rare. Adenoma, fibroma and fibro-adenoma have been observed. In several instances benign tumors have been successfully removed from the pancreas. Biondi[5] excised a fibro-adenoma from the head of the

[1] Revue de la Tuberculose, Serie 2, viii, 279.
[2] Thèse de Paris, 1911.
[3] Deutsch. Ztschr. f. Chir., 1912, cxix, 21.
[4] Jour. de méd. de Bordeaux, 1912, lxii, 428.
[5] Riforma med., 1896.

pancreas and reported the patient well two years after operation. Körte[1] removed a fibroma the size of a child's head (kindskopfgrösse) which was attached by a broad pedicle to the pancreas. The so-called adenomas of the islands of Langerhans, of which a number have been described, do not attain large size and are of no surgical importance.

Malignant Tumors.—Carcinoma is the most common tumor of the pancreas. Combined statistics indicate that it forms about 1 per cent. of all cases of carcinoma. It occurs both as a primary and as a secondary growth. Secondary carcinoma is somewhat more frequent than the primary form owing chiefly to the extension of cancer to the pancreas from the stomach. This occurs according to Oser in about 10 per cent. of all cases of gastric carcinoma. During ten years Germershausens observed in Munich 25 primary carcinomas, 32 metastatic carcinomas, 3 sarcomas (1 primary, 2 secondary), 1 cystofibro-adenoma, 1 gumma and 1 hemorrhagic cyst. In England and Wales, 1901–1907, there were 8 cases of pancreatic cancer to each 100 cases of gastric cancer in men. Fuchs, in a series of 67 cases, found secondary pancreatic cancer to be derived from the pylorus (29), remainder of stomach 16, duodenum 7, bile passages 13, and esophagus 2. It appears that the pancreas is frequently involved by carcinomatous growths in the adjacent viscera but seldom by metastasis from a distance.

Primary cancer arises from the ducts, the cells of the secreting acini and, according to Fabozzi, from the islands of Langerhans. The head is the portion most often affected as is seen in the subjoined figures.

	Mirallié, 68 cases.	Sayre, 57 cases.	Oser, 32 cases.
Head	39	35	20
Diffuse	19	19	1
Body	1	2	2
Tail	4	1	3
Head and body	3	0	0
Body and tail	1	0	0
Head and tail	1	0	0
Uncertain	0	0	6

The disease is more frequent in men than in women in the proportion of about 5 to 3.

To describe the parts which may be affected by the extension of the pancreatic growth would be to enumerate all the important structures in this vicinity so rich in essential organs. All the neighboring viscera, the bloodvessels, lymphatics, ducts and nerves may occasionally be attacked in accordance with the site of the growth and the direction of its extension. All such involvements may play a role in the symptomatology.

Symptoms and Diagnosis.—The cancers of the head of the pancreas give a fairly definite clinical picture. Not infrequently, however, growths in this region and especially those arising in other portions of the pancreas present the greatest variations from anything that may be regarded as typical.

[1] Deutsch. med. Wchnschr., 1909, xlix, 2153.

Pain is not usually a striking feature of pancreatic carcinoma, particularly when situated in the head of the organ. It may be entirely absent. Commonly there is some distress particularly in the later stages when involvement is widespread. When the solar plexus is invaded, which occurs more often in carcinoma of the body, the pain may be excruciating, simulating gastric crises as pointed out by Chauffard.[1] The pain of pancreatic cancer is deep-seated and tends to radiate to the back and lumbar region. It is not often colicky unless the biliary tract is also involved.

Jaundice is a cardinal symptom owing to the frequent compression of the common duct by the growth. It occurs in 60 to 70 per cent. of all cases. The time of its appearance is determined by the stage at which the growth permeates the periductal tissues. In cancer of the head this may be so early as to constitute the first sign of the disease. In other instances it may be lacking throughout. Occasionally jaundice comes on suddenly without prodromal symptoms, but the common experience is to observe first a slight tinge which gradually and steadily deepens into a dark greenish yellow that remains constant. Coincidently bile appears in the body fluids and disappears in the stools which take on the familiar character of acholic evacuations.

By obstruction of its own ducts of secretion carcinoma of the pancreas often adds to the signs and symptoms of biliary obstruction those of pancreatic insufficiency. Doubtless a chronic toxemia also results from retention of secretory products of the liver or the pancreas or both. In such cases the disturbance of digestion and absorption are extreme. Rapid emaciation and loss of strength occur and death usually follows in four to six months after onset.

Marked enlargement of the gall-bladder occurs in about half the cases of obstruction of the common duct owing to the unremitting back pressure within the hepatic ducts. When the gall-bladder has been diseased and robbed of its normal elasticity this does not take place. When present and palpable it is a valuable sign of obstruction of the common duct due to causes other than stone in the duct, as pointed out by Courvoisier, and when coupled with the symptoms of neoplasm the diagnosis is practically certain. It is important to note, however, that exceptions to this rule are occasionally seen.

Whether or not the tumor of the pancreas is palpable depends upon a number of conditions. Ordinarily pancreatic cancers do not attain a large size and are subject to the disadvantage that palpation as noted previously, is difficult owing to the deep situation of the growth, the overlying viscera and the thickness and resistance of the abdominal wall. As wasting occurs the tumor can be felt in many cases ($\frac{1}{4}$ to $\frac{1}{5}$ Mirallié; 20 of 50 cases, Boldt). As an early sign it is practically valueless.

Bard and Pic lay stress on a small and non-palpable liver in association with obstruction of the common duct as indicative of cancer.

[1]Bull. de l'Acad. de méd., 1908, xxii, 913.

Other observers do not agree as to the importance of this sign, but it is true that the liver is less apt to be enlarged in this disease than in conditions associated with interstitial hepatitis, such as cirrhosis, gallstones and cholangitis.

Glycosuria is more common than in inflammatory affections of the pancreas. It is rarely an early symptom. On the other hand, it has been observed in the earlier stages only to disappear with the advent of extreme cachexia. Miralliè, in 50 collected cases found glycosuria noted in 13. In 2 of the remaining 37 there was noted a lowered tolerance for glucose.[1] In a small percentage of cases it may occur in a transitory and intermittent form and occasionally in diffuse carcinomatosis of the organ or when a high-grade destructive inflammatory process has been engrafted upon the carcinomatous obstruction of the duct, true diabetes with its characteristic symptoms are seen.

Signs of interference with pancreatic digestion, such as undigested food particles in the stools and diminished ferment content of stools and duodenal contents go hand in hand with blockage of the pancreatic duct.

Edema and ascites are rare manifestations due to compression of the portal vein or the vena cava.

Loss of appetite and anemia are progressive. The temperature does not vary greatly from normal.

Bearing in mind the many variations which may occur, the characteristic picture of the disease begins with mild but increasing symptoms of indigestion soon followed by jaundice which is not ushered in by an exacerbation of pain but gradually and steadily increases without remission. Intense pain, if it occurs, follows the well-marked signs of serious disorders. Loss of weight, and of appetite with weakness and prostration rapidly come on and the whole course is commonly run within a year.

From a practical standpoint the chief surgical interest in malignant disease of the pancreas has to do with its differentiation from other conditions which are remediable by operation. Cancer of the pancreas may occasionally be simulated by chronic pancreatitis, atypical cases of stone obstruction of the common duct and, rarely, by periductal tuberculosis or glandular enlargement of inflammatory nature. Carcinoma of other organs in the neighborhood also may be indistinguishable but the prognosis is not improved thereby.

The safest rule is to explore such cases early in the hope that a nonmalignant condition may be found and remedied. This is particularly imperative in cases that are in any way atypical.

Sarcoma is a very infrequent primary tumor of the pancreas. Guleke[2] in 1912 was able to collect only 12 cases reported in the previous ten years. Kakels[3] had prior to that time collected 10 cases. Secondary sarcoma occasionally occurs in general sarcomatosis. In its course and prognosis sarcoma does not differ materially from carcinoma.

[1] Gaz. d. Hôp., 1893, lxvi, 389.
[2] Loc. cit.
[3] Am. Jour. Med. Sc., 1902, cxxiii, 471.

Treatment.—No permanent recovery from pancreatic cancer has been reported. In view of the insidious nature of the disease and the impossibility of carrying out the cardinal principle of the treatment of cancer, namely, the removal of the regional lymphatics with the primary growth, it does not seem hopeful that surgery, however early, can accomplish this result, except perhaps in fortunately discovered early and local instances. Partial and total extirpation of the organ are, however, surgical possibilities. Billroth in 1884 removed the whole pancreas for malignant disease and the patient recovered temporarily. Franke in 1901 excised the whole organ for cancer. The patient died of recurrence five and a half months later. According to his report glycosuria appeared for a few days after the operation and then disappeared entirely. The difference between this behavior and that which from animal experimentation we believe to be the result of pancreatectomy may be explained by his noting a small mass beneath the head of the pancreas which Franke thought to be a supernumerary pancreas and left untouched. Or it may be due to the possibility of metastatic carcinomatous nodules maintaining the carbohydrate metabolism by their internal secretions, or finally it is possible that a vicarious function may be set up in such cases which obviates the usual metabolic consequences of pancreatectomy. We have previously mentioned a case of pancreatic stone which apparently caused total destruction of the pancreas, yet without diabetes. These factors await further observations. At present there is no good reason to suppose that total pancreatectomy is anything but "jumping out of the frying pan into the fire."

Partial extirpation of the pancreas has been carried out, according to Glaessner[1] 28 times, with 14 operative recoveries and 14 deaths. The pancreas is not the *noli me tangere* that it was thought to be a few years ago. Mayo has shown that excision of superficial portions of the pancreas when it is involved by gastric carcinoma but slightly increases the mortality of operation, which is in sharp contrast to the much quoted opinion and statistics of Mikulicz and Haberkant. Superficial wounds of the pancreas may be treated by oversewing with catgut to stop the bleeding after which the area should be covered by a portion of mobilized omentum. In gastric resections Mayo[2] stitches the stump of the duodenum to the cut surface of the pancreas. At first he drained, but has now found it unnecessary. In these cases the main ducts of the pancreas were not opened. In 3 cases Mayo wounded the tail of the pancreas during splenectomy. In 1 case the injured surface was covered with omentum. Drainage was used but not needed. In a second case the tail was tied in the pedicle. Owing to the condition of the patient the pedicle was dropped back without further precaution. The patient recovered. In a third case the tail was crushed and tied and a second ligature applied about the pancreas one inch nearer the head. The patient recovered without symptoms.

[1] Deutsch. Klin., 1913–14, Ergänzgsb., iii, 217.
[2] Ann. Surg., 1913, lviii, 145.

These experiences serve to show that under proper conditions wounds, ligatures and resections of the pancreas are not attended by prohibitive dangers.

Desjardins[1] has devised an ingenious method of resection of the head of the pancreas. Sauvè[2] has reported three cases in which the operation was done, and Lotheissen[3] succeeded once in removing the pancreatic head for tumor. In this operation the duodenum is removed, a posterior gastrojejunostomy made and the common duct and the stump of the pancreas placed in communication with the intestine by one of several maneuvers which have succeeded experimentally. The pancreatic stump has also been drained externally. None of these operations can at the present time be commended as other than experimental and to us it would seem to be unjustifiable to perform them in any case which did not hold out hope of ultimate recovery.

Partial resection of the body or tail of the organ is a much simpler surgical procedure and will be indicated in certain instances. As a means of treatment of malignant disease of this portion of the pancreas its employment is limited by the fact that disease in this situation gives no early diagnostic symptoms of its presence. Pancreatic tumors do not occur in such form that enucleation is possible. In the event that excision or transection of the pancreas is necessary what is to be done with the defect? Shall suture or drainage be employed? And should that portion of the pancreas which is distal to the disease be removed when its ducts are severed? Körte advises against limited excisions. The results of subcutaneous rupture show, however, that pancreatic tissue which is disconnected from the duodenal end of the duct of Wirsung may be retained without permanent fistula or other ill-effects. It should be remembered also that the tail of the pancreas is the portion which is richest in the islands of Langerhans and therefore probably most important from the aspect of its internal secretion. These do not disappear even though the acini undergo complete atrophy. Finney[4] reports a successful case of resection of the body of the pancreas for removal of a cystadenoma. The two ends were accurately united by mattress sutures of catgut. A cigarette drain of iodoform gauze was placed about the line of suture. A fistula developed after the operation which discharged pancreatic fluid for about three months. Six months later the patient was in excellent health.

At present we may say that the indications are that drainage should always be employed in cases that suffer injury to the main pancreatic duct, or in case of doubt: that repair of defects may be undertaken when it can be done without doing violence to the remaining pancreas, not with the idea of again placing that portion in communication with the severed ducts, but in order to restore anatomical relations and obliterate dead spaces, and lastly, that those portions of the pancreas which are

[1] Rev. de chir., 1907, xxxv, 945.
[2] Ibid., 1908, xxxvii, 113, 335.
[3] Wien. klin. Wchnschr., 1903, xvi, 409.
[4] Ann. Surg., 1910, i, 818.

not diseased should be left because of their possible importance in metabolism.

In general the operations employed in the case of tumors of the pancreas resolve themselves into three classes:

1. *Exploratory.*—A legitimate doubt as to the diagnosis exists in many cases and a slight doubt in almost all. This justifies exploration in all cases where it is not contra-indicated by incontrovertible signs of malignant disease or by the condition of the patient.

2. *Radical operation* may be undertaken when there is a reasonable belief that it is possible to remove the disease *in toto.* In benign conditions this should always be considered in relation to the special operative difficulties to be met. In malignant disease we leave the question open for the future. We have never seen a case which seemed to offer any hope of permanent cure, and in our opinion to operate radically upon a hopeless condition is unjustifiable unless palliation be the object. There is no evidence at the present time to encourage operation on this account.

3. *Palliative Operation.*—Obstruction to the common bile duct may be overcome by cholecystoduodenostomy preferably, or by cholecystogastrostomy or by cholecysto-enterostomy. Mechanical conditions will indicate which operation is to be employed. Ochsner recommends cholecystojejunostomy through an opening in the transverse mesocolon when the duodenum cannot be used for the anastomosis.

Pancreatico-enterostomy may be thought of for relief of pancreatic obstruction. Experimentally it is performed readily and with success upon animals. In the human subject the technic is more difficult because of anatomical conditions and the chances of success are less.

Of both these operations it may be said that they are likely to be less productive of improvement than is expected. Certainly this is the experience with side-tracking the bile into the intestine. By the time the disease has caused obstruction of the ducts and attained sufficient development to justify a positive diagnosis the involvement of other viscera has occurred and the patient is started on the rapid down grade that cannot be palliated by this simple procedure. The mortality of the operation, particularly in cases of chronic jaundice is considerable. Itching is a prominent symptom of many cases of carcinoma of the head of the pancreas and if intolerable, warrants a cholecystoduodenostomy.

A legitimate field for such operations exists in cases of reasonable doubt as to the diagnosis. It is not always possible for the surgeon to distinguish between benign and malignant sclerosis of the head of the pancreas. A palliative operation under such conditions may have an unexpectedly favorable outcome. Cholecystotomy is usually to be avoided for the reason that it fails to preserve for the patient the secretion of bile, and if the obstructive process too be lasting, as is usually the case, his misery is increased by the persistent fistula.

SURGERY OF THE SPLEEN.

By WILLIAM J. MAYO, M.D.,

AND

ALEXANDER ARCHIBALD, M.D.

ANATOMY OF THE SPLEEN.

The greater part of the spleen is situated in the left hypochondrium. The upper pole extends inward to within one inch of the vertebral column at the level of the ninth dorsal spine and thus comes to lie in the epigastric region. The lower pole corresponds to the level of the first lumbar spine, further from the spine than the upper pole and more anteriorly. The axis of the organ is therefore downward, forward and outward and corresponds with the long axis of the tenth rib.

The spleen resembles an irregular tetrahedron in its shape which, however, varies greatly according to the pressure exerted on it by surrounding organs. It is well protected by the ribs, lies deep in the abdomen back of the stomach and splenic flexure, and is held in position by folds of the peritoneum. The layers of the gastrosplenic omentum separate as they reach the hilum of the spleen. The posterior layer turns backward, crosses the anterior surface of the left kidney and continues to the right, forming the posterior wall of the lesser peritoneal sac. The anterior layer envelops the organ to which it is firmly attached and when it reaches the hilum posteriorly it is flexed backward to the anterior surface of the left kidney and then to the diaphragm. These two layers form a double fold, which constitutes the lienorenal ligament. Another fold of peritoneum extending from the diaphragm to the colon, the phrenocolic ligament, forms a support to the spleen.

The spleen has two coats, the outer peritoneal and the inner fibro-elastic. At the hilum the inner coat is prolonged inward and forms the sheaths for the bloodvessels. From these sheaths as well as from the inner aspect of the fibro-elastic coat trabeculæ are given off which unite to form the true framework of the spleen (Fig. 236). The spaces so formed contain the splenic pulp. The spleen contains non-striated muscle fibers.

The normal movements of the spleen are usually more limited than those of the liver. The position of the spleen is affected to some extent by the respiratory movements and also by pathological conditions of the chest and abdomen.

The size and weight of the spleen vary to some extent under normal physiological conditions. In a normal adult its length is from 10 to 13 cm., its width 7 cm. and its thickness 3 cm. The average weight is about 200 grams.

The spleen has two main surfaces, the parietal, or convex surface, and the visceral, or concave. The former is separated from the ninth, tenth and eleventh ribs by the diaphragm and at its upper portion by the pleura and lung also. The visceral surface, which faces downward, forward and inward, is in contact with the stomach, splenic flexure, left kidney and the tail of the pancreas. At the lower aspect of this surface there is a rounded eminence, the internal basal angle, from which rounded borders diverge and separate the gastric, renal

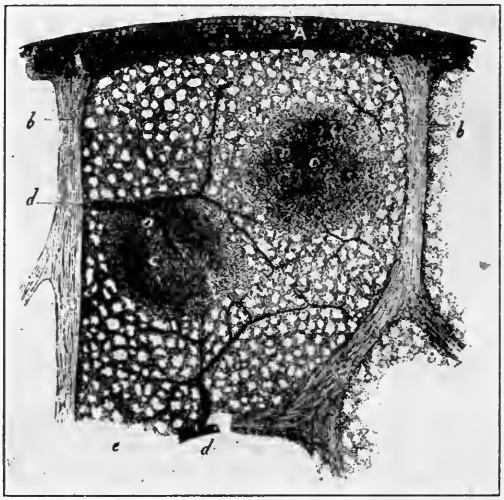


FIG. 236.—Vertical section through a fragment of human spleen, low magnification. *A*, peritoneal and fibrous capsule; *b*, *b*, trabeculæ; *c*, *c*, Malpighian corpuscles, one of which shows the transverse section, and other the long section, of an artery; *d*, injected arterioles; *e*, splenic pulp. (Kolliker.)

and basal surfaces. The gastric surface, which is largest, lies in front and is in contact with the fundus of the stomach. The anterior border, which is usually notched, separates this surface from the parietal surface. The tail of the pancreas is in contact with the lower portion of the gastric surface anterior to the internal basal angle. The renal surface, which lies posteriorly, is in contact with the upper half of the left kidney and suprarenal capsule. The basal area, which is the smallest, is in close relationship to the splenic flexure and the phrenocolic ligament. The hilum of the spleen is situated at the posterior aspect of the gastric surface and here the bloodvessels enter and leave the spleen. Accessory splenic tissue is often found in separate nodes from the size of a pea to a walnut, in the folds of the splenic pedicle.

Blood Supply.—The splenic artery, the largest of three branches of the celiac axis, pursues a very tortuous course outward along the upper border of the pancreas and before entering the hilum it divides into five to eight branches which lie between the layers of the lienorenal ligament. These divide and subdivide and ultimately form terminal arteries in the splenic substance. The vasabrevia consist of five to seven small branches which arise either from the termination of the splenic artery or its terminal branches and passing between the layers of the gastrosplenic omentum, are distributed to the greater curvature of the stomach. Numerous small arteries are given off to the pancreas as the artery passes behind that organ. The splenic vein is formed by several large branches which leave the hilum; it runs a straight course behind the pancreas at a lower level than the artery, and joins the superior mesenteric vein behind the head of the pancreas to form the portal vein.

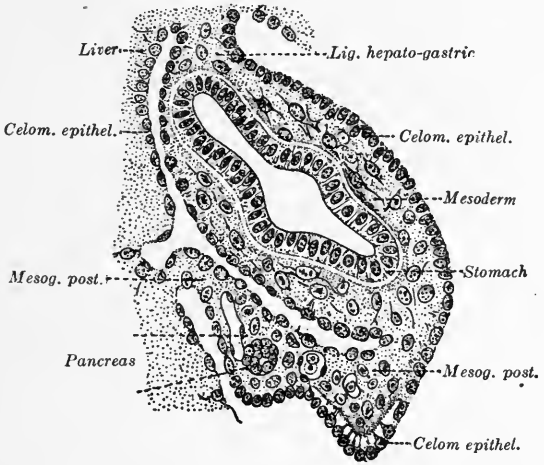


FIG. 237.—Anlage of the spleen in the posterior mesogastrium of a human embryo 10.5 mm. long. × 30. (After Kollmann.)

Lymphatics.—The lymphatics, which are scanty, originate in the arteries and in the trabeculæ. The former consist of deep trunks which follow the bloodvessels and finally enter the splenic glands at the hilum; the latter form the superficial lymphatic plexus and also enter the splenic glands at the hilum; both systems communicate with each other within the spleen.

Nerves.—The nerve supply is derived from the solar plexus and enters the spleen with the bloodvessels.

Embryology.—Müller,[1] in 1871, was the first to demonstrate that the spleen is of mesodermal origin. He described the splenic anlage as a thickening of the peritoneum early in the life of the embryo. The

[1] Asher, L., and Ebnöther, G.: Centralbl. f. Physiol., 1915, xxx, 61–64.

spleen arises from a thickening of the dorsal mesogastrium and can be seen in embryos as early as the fifth week 8 to 10 mm. long. As shown in Fig. 237, it is in close relationship to the stomach and omentum. Told, in 1889, found that part of the mesodermal anlage of the spleen is derived from the celomic epithelium, which is several layers thick over the splenic anlage. The deepest of these cells are transformed into mesenchyme cells. The vascular system of the spleen at first consists of a fine network of capillaries similar to the primitive circulation of other organs, later in embryonic life this is transformed into a cavernous circulation. When the fetus is between 10 and 12 cm. long, the spleen enlarges quickly owing to the rapid development of its vascular system. At this time spherules of capillaries can be seen, especially at the edge of the spleen. These connect the arterial and venous systems and later form the splenic pulp which, as was proved by Mall, connects these two systems in the adult spleen. The Malpighian bodies are the result of a collection of lymphocytes in the adventitia of the arteries and the development of the adventitia during which process the connective-tissue fibrils are laid down in concentric rings around the arteries. In the embryo of six months the spleen has acquired its triangular shape and the capsule and Malpighian bodies can be easily differentiated.

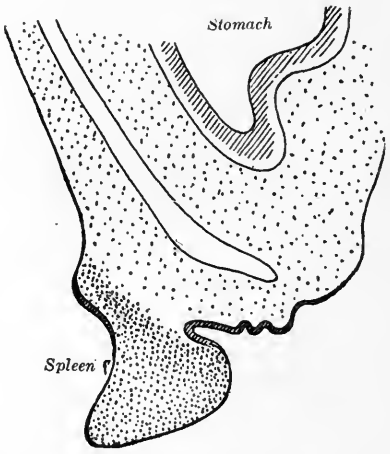


FIG. 238.—Diagram of the spleen, showing its relations to the stomach and the omentum in a human embryo 20 mm. long. (After Tonkoff.)

PHYSIOLOGY OF THE SPLEEN.

The splenic arteries have already been described as having a fibrous sheath. After dividing and subdividing they ultimately lose this sheath and it is replaced by one of lymphoid tissue. The arteries end in a loose network of capillaries, the endothelium of which is directly continuous with that of the small spaces of the splenic pulp. The spleen is thus unique in that the blood comes in direct contact

with its tissue elements. The veins begin in a similar capillary network and unite to form larger veins. The splenic pulp is essentially composed of cells which are embedded in a fibrous network. This

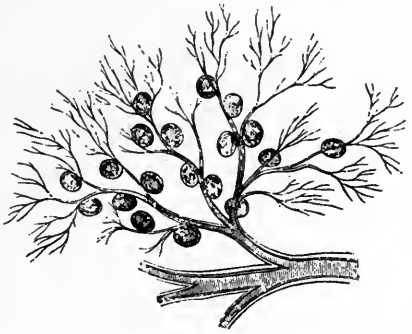


FIG. 239.—Small splenic arterly (dog), with many Malpighian corpuscles attached to the perivascular lymphatic sheath. Magnification of 10 diameters. (Kölliker.)

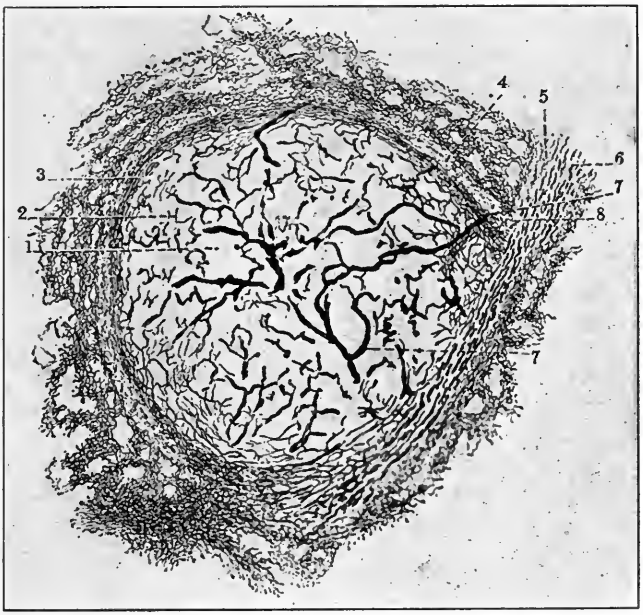


FIG. 240.—Section of Malpighian corpuscle and surrounding tissue of splenic pulp, with injected network of blood capillaries, treated with silver chromate; highly magnified. (Oppel.) *1*, Malpighian corpuscle; *2*, part of its reticulum; *3*, denser reticulum at the edge of the corpuscle; *4*, looser tissue external to the former; *5*, *6*, connective tissue of arterial sheath, to which the corpuscle is adhering; *7*, capillaries of corpuscle; *8*, reticulum of pulp surrounding the arteriole.

network is formed by minute trabeculæ and the branchings of large nucleated cells. The cells in the meshes of the network are in part composed of granular corpuscles which have ameboid movement. They are also red blood cells and cells containing pigment similar to

hematin. The Malpighian bodies are situated on the small arteries (Figs. 239 and 240). They are outgrowths of the lymphoid sheath and can be seen by the naked eye as small whitish spots.

The spleen is the largest of the ductless glands and, like other members of this group, very little is definitely known with regard to its function. On reviewing the literature, which is very abundant, one is impressed with the great confusion that exists. In nearly every sphere of research concerning the spleen conclusions reached by one physiologist have been contradicted by the experience of another. This may be partly accounted for by the fact that theories are often advanced which lack sufficient experimental evidence. Pearce and his co-workers have demonstrated that numerous intricate and complex problems must be solved if any advance is to be made in the knowledge of the functions of the spleen. Very little has been attained that would aid us in the treatment of diseases apparently due to some abnormality in the splenic function. We rely mainly on clinical observations for our methods and procedures. Whatever the function of the spleen may be, it would seem that its removal does not materially affect the health and welfare of the human being. Numerous cases of injury of the spleen are reported in which splenectomy was necessary and those patients who recovered from the accident and the operation apparently suffered no ill effects and were able to resume their usual duties. As will be mentioned later, it is possible that the loss of the spleen is compensated for by other organs, especially the lymphatic and hemolymphatic glands. Clinical experience teaches us that changes in the blood are more marked after removal of a recently injured spleen than after removal of the diseased spleen. This can be explained by the fact that in diseased conditions compensatory changes have been in progress over a more or less prolonged period previous to splenectomy. It has been stated that splenectomized persons are more liable to contract current infectious diseases. The truth of this would seem doubtful. The resistance against infectious diseases once they are contracted is evidently not affected by splenectomy. Postoperative infections are no more serious following splenectomy than other operations. A few cases have been reported in which the spleen was congenitally absent.

The most important changes observed after splenectomy for injury to normal spleens are those which occur in the blood. There is an increase in the number of leukocytes characterized by a relative increase of mononuclears. The maximum number is usually reached in about twelve days. At first the erythrocytes decrease in number, but in a few days they increase with the simultaneous rise in percentage of hemoglobin. It has been observed that a moderate eosinophilia usually occurs some months after the operation and may persist several years.

Functions.—Most observers agree that the spleen has the power to destroy red blood cells which have completed their life cycle. This

view has a more uniform support than any other function with which the spleen is credited and has for its basis the following points of evidence: (1) The presence in the spleen of red blood cells in various stages of disintegration; (2) the presence in the spleen of large ameboid cells which contain broken down red blood cells; (3) the abundance or organic compounds rich in iron, probably derived from the red blood cells which have been digested; (4) the fact that after splenectomy the lymphatic and hemolymphatic glands become hyperplastic, that they even increase in number and possess an augmented ability to devour erythrocytes. As a result of experimental work, Asher[1] concludes that the spleen contains a substance which is but slightly hemolytic in itself, yet when acting in combination with liver extract forms a powerful hemolytic agent.

It has been asserted that the spleen takes part in the production of red blood cells in adult life. This is probably one of the most doubtful functions assigned to the spleen and has little to substantiate it. Such a function may exist in fetal life and perhaps in early childhood. As shown by Bizzozero,[2] the red blood cells in fish and lower reptiles are formed in the spleen exclusively. In birds the spleen and bone marrow both take part in this function; but as we ascend the scale of vertebrates the bone marrow becomes more important and in man it probably is the only source of red blood cells. It is possible, however, that the spleen may exert some controlling influence over the production of erythrocytes; if such a role is carried out by the spleen, we are still ignorant as to the manner in which it is accomplished.

That the spleen aids in the formation of leukocytes is advanced by Halliburton[3] chiefly because a greater number of white corpuscles is found in the splenic vein than in the artery and because of the fact that the spleen is hypertrophied, and especially the Malpighian corpuscles in the leukemias in which white blood cells exist in such abnormally large numbers. In splenic anemia Banti believes that the leukopenia is due to a decreased output of leukocytes, a result of the diseased condition of the spleen.

Because of the presence of such nitrogenous compounds as xanthin, adenin, uric acid, etc., it is thought that the spleen plays an important part in metabolism. It was shown by Horbaczewsky that the spleen contains substances from which uric acid can be formed by the action of the spleen substance itself. More recently it has been shown that the spleen contains enzymes—oxidase, adenase and guanase—which can produce uric acid from the split products of the nucleins. Another theory is supported by Schiff who asserts that the spleen contains an enzyme which, when carried to the pancreas, converts trypsinogen into trypsin.

During digestion the spleen is supposed to act as a kind of reservoir to the portal system and helps to regulate the blood supply. Soon

[1] Asher, L., and Ebnöther, G.: Centralbl. f. Physiol., 1915, xxx, 61–64.
[2] Virchows Arch., xcv, 1–25. Quoted in Keen's Surgery, Philadelphia, 1908, ii, 1070.
[3] Handbook of Physiology, Philadelphia, 1914.

after the meal the spleen begins to enlarge and reaches its maximum in five or six hours; it then returns gradually to normal size. With regard to the changes in the size of the spleen, the demonstrations of Roy are probably the most important. He has shown that in cats and dogs a rhythmical contraction occurs about once every minute. This is brought about by the non-striated muscular fibers which are present in the capsule and trabeculæ. This rhythmical movement probably helps to promote circulation through the large splenic spaces; its real significance, however, remains undetermined.

Pearce and his co-workers[1] found that on the injection of a powerful hemolytic serum an extreme laking of the erythrocytes occurred in both splenectomized and non-splenectomized dogs; on the injection of a weak serum jaundice was more readily produced in non-splenectomized than in splenectomized dogs. Further experiments led them to the conclusion that this result was due in some way to the anemia that usually follows splenectomy because anemic animals do not readily develop jaundice after the injection of hemolytic serum whether or not the spleen has been removed. If anemia does not exist, such a serum will produce jaundice shortly after splenectomy. The difficulty of producing jaundice in dogs one month or more after splenectomy seems to be due to an increased resistance of the red cells. Pearce and Karsner[2] think that the anemia and the increased resistance of the red cells are not due to any acquired property of the serum and conclude that the spleen controls and regulates blood destruction and possibly regeneration. In an attempt to explain the production of anemia, Pearce and Austin[3] studied the lymph nodes and liver after splenectomy. They found a great increase in the endothelial cells of the lymphatic glands which were phagocytic for red cells. The stellate cells in the capillaries of the liver also had the same property. From this it was suggested that the lymphatic gland and possibly the liver compensate to some extent for the loss of the spleen but they are unable to say if the changes in the lymph glands account for anemia.

Warthin,[4] working in the sheep, found a marked increase in the number of lymphatic glands as well as hyperplasia and also found new formation of hemolymphatic glands following splenectomy.

It is a well-known fact that the spleen is probably always enlarged in infectious diseases and in intoxication. Very often, indeed, it is so enlarged as to be palpable below the costal margin. Such spleens are markedly congested and may show areas of inflammation and sclerosis. We are still ignorant as to the significance of this enlargement and change in structure but it would seem probable that the spleen, with the other lymphatic structures of the body, acts as a barrier and protects the body against microörganisms and their products.

[1] Pearce, R. M., Austin, J. H., and Krumbhaar, E. B.: Jour. Exper. Med., 1912, xvi, 363–394; Pearce, R. M., Austin, J. H., Musser, J. H.: Ibid., pp. 758–768.

[2] Ibid., pp. 769–779.

[3] Ibid., pp. 780–788.

[4] Contributions to Medical Research dedicated to Victor C. Vaughan, Ann Arbor, Wahr, 1903, pp. 216–236.

INJURIES OF THE SPLEEN.

Injury to the spleen may be of three kinds: (1) protrusion or prolapse of the organ through a rent in the abdominal or chest walls; (2) penetrating wounds; (3) subcutaneous rupture. The spleen may penetrate the diaphragm in traumatic diaphragmatic hernia.

Prolapse.—Prolapse of the spleen is exceedingly rare It may occur through a rent in the upper abdominal wall or the lower left chest. The organ itself may be seriously damaged or it may be unharmed. If the organ has remained uninjured it should be replaced after thorough cleansing. If the injuries are extensive, splenectomy should be performed. Minor injuries may be attended to by suturing, crushing the edges of the wound or tamponade and, after careful search for bleeding points, the spleen returned within the abdomen. Splenectomy, however, would seem to be the rational treatment on account of the complications that may result from hemorrhage or secondary infection after other forms of treatment.

Penetrating Wounds.—Penetrating wounds may be due either to gunshot or stabbing. In the large majority of cases other organs also are injured. Any of the several organs of the abdomen or chest may be damaged, depending on the direction of the bullet or instrument of injury. Death, as a rule, speedily follows on account of the extensive hemorrhage so that immediate operation is indicated. Judging from the literature on the subject, it would seem that suture of the wounded organ is attended with better results than splenectomy. It is possible, however, that in these cases in which splenectomy was performed the injury was extensive and the patients in a very critical condition.

Injuries to the spleen during the World War carry apparently the same indications for treatment as injuries in civil practice. Available statistics show that when the spleen alone is injured at least 50 per cent. of patients will recover by surgical treatment, which may be by suture, by tamponage or by splenectomy.

The experience of those who have seen the largest number of such cases indicates that splenectomy is the preferable operation if the spleen is badly lacerated. It would seem reasonable that this is true because of the low mortality associated with the removal of the spleen. The fact that the majority of cases, however, are complicated by injuries to other organs in the abdomen means a higher mortality. Wallace,[1] for example, reported 63.6 per cent. in complicated cases.

Subcutaneous Rupture.—The normal spleen is well protected from external injury by the lower left chest wall. In accidents where the spleen is ruptured it will very often be found that a pathological condition existed previously and resulted in enlargement and friability of the organ. As a rule, the lesions are very extensive and may be produced by slight external violence. Cases have been reported in

[1] A study of 1200 cases of gunshot wounds of the abdomen. Brit. Jour. Surg., 1917, iv, 679-743.

which the organ was torn into several parts, some of which were free in the abdominal cavity. Severe hemorrhage is apt to occur, producing speedy death but at operation cases with marked lesions accompanied by but slight loss of blood have been encountered. The hemorrhage in these cases is usually limited by adhesions which serve to control the flow of blood and favor clotting. Fauntleroy[1] reports a case in which the patient fell forty feet, receiving marked contusions of the left abdomen and left chest. The patient's general condition remained favorable and there were no signs of hemorrhage but on account of persistent left abdominal rigidity in connection with pain and a slight tendency to nausea, the abdomen was opened three hours after the accident. The spleen was found completely torn across about its middle, but there had been very little hemorrhage. Only one large clot was found surrounding the spleen and it was thought that the extensive adhesions which were present helped to control the hemorrhage. Scheult[2] reported a case which presented very slight symptoms at the end of forty-eight hours notwithstanding the fact that the patient had a long and rough journey before admittance to the hospital. At operation the spleen was found divided into three parts.

Spontaneous Rupture.—Spontaneous rupture of an acutely swollen organ may occur as a rare complication in some of the acute specific fevers. It seems to take place with greatest frequency in malarial fever but has been encountered in typhoid fever, typhus fever and relapsing fever. Noland and Watson[3] found that in 30,000 malarial cases admitted to the Colon Hospital in eight years there were 3 cases only of spontaneous rupture. Conner and Downes[4] reported spontaneous rupture in a typhoid fever patient and were able to collect only 12 other cases.

Symptoms.—The symptoms may be divided into those caused by the local condition together with irritation of the peritoneum, and those due to severe internal hemorrhage. In traumatic rupture, of course, there is a history of injury. The site of injury is usually localized in the left hypochondrium or lower left chest. There may be severe external contusions or there may be no signs whatever of external violence. Recorded cases show that the death-rate is very high and generally death occurs within twenty-four hours. Almost immediately after the injury the patient experiences severe sharp pain in the left hypochondriac region. Symptoms and signs of severe hemorrhage develop very rapidly, *e. g.*, vomiting, rapid weak pulse, shallow rapid respiration, cold and clammy skin. On the other hand, urgent symptoms may not be present and the patient feels well except for local pain in the region of the spleen. In these cases hemorrhage is very slight. Fauntleroy's[5] patient experienced severe deep-seated pain in the left shoulder. Fauntleroy attaches a great deal of impor-

[1] Ann. Surg., 1913, lvii, 68–71.
[2] Lancet, 1913, ii, 794–795.
[3] Ann. Surg., 1913, lvii, 72–80.
[4] Am. Jour. Med. Sc., 1914, clxvii, 332–344.
[5] Am. Surg., 1913, lvii, 68–71.

tance to this symptom, especially as it was relieved after operation. The case reported by Conner and Downes also displayed a similar symptom so that when present it may aid in making a diagnosis. On examination, the entire abdominal wall may be found more or less rigid, or the rigidity may be localized to the left hypochondrium and accompanied by tenderness. On percussion, there is dulness in both flanks usually elicited if the hemorrhage has been extensive. According to Ballance persistent dulness in the left flank even when the patient is turned over on the right side should at once turn our attention to the spleen.

Diagnosis.—It is very difficult to arrive at a definite diagnosis of rupture of the spleen, especially of spontaneous rupture. The 3 cases reported by Noland and Watson were all operated on for supposed intestinal perforation. In the case reported by Conner and Downes the diagnosis of ruptured spleen was made previous to operation. In traumatic rupture the site of injury will attract attention to the spleen and if the above signs and symptoms are present diagnosis is possible.

Treatment.—The treatment of ruptured spleen is entirely surgical. Even if a diagnosis has not been arrived at there are other abdominal signs and symptoms which indicate immediate surgical procedure. Several methods may be adopted: (1) suture of the tear; (2) tamponade; (3) crushing the edges of the wound followed by suture; (4) splenectomy. Where the rent is small, suturing may suffice, but a careful search must be made for bleeding points before the spleen is returned to the abdomen. Senn,[1] experimenting with dogs, found that hemorrhage could be arrested by crushing the edges of the wound and stitching the crushed edges together.

WANDERING SPLEEN.

As already stated, the spleen is held in place by the lienorenal ligament, costocolic ligament and the gastrosplenic omentum. Under normal conditions its range of movement is very limited. It is extremely unusual to be able to palpate the edge of the normal spleen, save in children; where this is possible in the adult an enlargement probably exists. The pedicle of the spleen, however, may become so elongated as to allow the organ to occupy any part of the abdominal cavity, and even the pelvis. The wandering spleen usually possesses greater freedom than any other abdominal organ which may assume similar characteristics. In the majority of cases its abnormal movements are limited to the left abdomen, but cases are reported in which the spleen has been found in the right iliac fossa and bony pelvis. In one case it was found to occupy the sac of an inguinal hernia.

Etiology.—It is probable that abnormal mobility of the spleen may be due to congenital elongation of the pedicle as was present in a

[1] Jour. Am. Med. Assn., 1903, xli, 1241–1245.

boy, aged twelve years, reported by Moynihan.[1] An abnormal laxity of the splenic ligaments must be considered as the chief factor in many cases because a wandering spleen may be present in the strong, healthy individual whose abdominal muscles possess proper tonicity and whose organs with the exception of the spleen are in normal position. In most cases, however, some secondary condition is present, possibly a flabby abdominal musculature resulting from repeated pregnancies, ascites, etc., or a ptosis of all the abdominal organs may exist. Enlargement of the organ would seem to be only an exciting cause. In conditions such as splenic anemia and leukemia in which the largest spleens are found, abnormal mobility very seldom exists; this fact is due partly no doubt, to the perisplenitis and adhesions which accompany these diseases. In most cases of wandering spleen there is enlargement of the organ but the increase in size may be the effect rather than the cause of the abnormal mobility.

Pathology.—The pathological changes are usually due to mechanical influences on the circulation. As a result of kinking or twisting of the pedicle the spleen is very often enlarged and congested and an increase in connective tissue results. Where the pedicle has become acutely twisted large subcapsular hemorrhages or even rupture of the spleen may be found. This may be followed by necrosis and the formation of abscess. Perisplenitis may be present, causing adhesions and fixation of the organ in some abnormal position.

Symptoms.—The spleen may have an extremely wide range of movements and produce no symptoms whatever. Such spleens have been discovered in the course of routine examinations. The most common symptom is a dull dragging pain in the left hypochondriac region and in the majority of cases the patient has already discovered a tumor which may be pushed about in the abdominal cavity. Occasionally the organ becomes fixed and may produce a variety of symptoms, depending on its location and the organs with which it interferes. There may be nausea and vomiting, loss of appetite due to dragging of the stomach. There may be renal, vesical, intestinal or uterine disturbance. In the case reported by Webster and Tieken[2] there were at times symptoms from the kidney, bladder, intestines and uterus, during the course of the illness. The renal symptoms were so marked that a pathological condition of the right kidney was diagnosed. In this case, the spleen was fixed in the right iliac fossa and during a period of seventeen years the patient experienced severe attacks of pain with vomiting, fever and shock. At operation, an enlarged adherent spleen was found having three complete twists in the pedicle. It was adhered to the omentum, intestines and right iliac fossa, the uterus and right appendages. Under such conditions one can readily understand the variety of symptoms that can be produced and the difficulty of arriving at a diagnosis. If the pedicle suddenly becomes twisted the patient presents acute symptoms and very rapidly becomes

[1] Loc. cit., p. 1073.
[2] Jour. Am. Med. Assn., 1903, xl, 887–891.

seriously ill. Sudden intense pain is experienced in the region of the tumor, vomiting, weak, rapid pulse and symptoms of shock. Immediate surgical measures are usually indicated but if the torsion becomes undone and the pedicle relaxes the symptoms may all subside. Repeated attacks, however, are liable to occur as in the case reported.

Diagnosis.—The diagnosis is often very difficult especially if the organ becomes fixed in some remote position such as the right abdomen or pelvis. If in such a case an acute torsion of the pedicle takes place difficulties may arise which render a definite diagnosis impossible. In the uncomplicated cases, diagnosis is usually easy. A tumor having the contour edge and notch of the spleen which can be replaced in the splenic region is easily identified. The absence of normal splenic dulness may be suggestive.

Treatment.—In those cases in which a wandering spleen is discovered accidentally and the patient is free from symptoms, it is probably advisable to refrain from surgery. Abdominal supports of various kinds may be tried but their efficacy is questionable. If the patient is inconvenienced by this condition, splenopexy may be resorted to; wandering spleens treated in this way seem to have remained in the normal position in reported cases. As a rule, the spleen is enlarged and so diseased as to indicate splenectomy. In recent years this operation has been attended with a very low mortality and in the majority of cases is the one to be selected.

Mayo[1] advises splenectomy as splenopexy does not always relieve symptoms. He has operated on 3 cases, 2 by splenectomy, 1 by splenopexy. In splenectomy cases the patients obtained complete relief. In the third case the spleen remained in place, but the patient suffered more or less pain afterward.

SURGICAL DISEASES OF THE SPLEEN.

Tumors.—The spleen is very rarely the site of tumor formation either primarily or secondarily to some other focus. Its mechanical protection against injury may partially account for its immunity to primary growths. No satisfactory explanation, however, has as yet been advanced as to why such a vascular organ is so rarely involved in neoplastic processes. Simple tumors such as fibroma and adenoma have been described by pathologists, but apparently have never been encountered by the surgeon. Malignant tumors may be primary or secondary. There has never been a convincing case of primary cancer of the spleen reported (Bush[2]), so that primary malignant growth is confined to the consideration of the sarcomas. It is doubtful that all the reported cases are true sarcomas. Some cases have been reported as such and later were found to be the result of a marked proliferation of endothelioid or lymphoid elements which may exist in other forms of splenomegaly. Some of the cases of surgical cure may belong

[1] Surg., Gynec. and Obst., 1913, xvi, 233–239.
[2] Jour. Am. Med. Assn., 1910, liv, 453–456.

to this category. There are three different types of connective tissue from which sarcoma may originate: (1) capsular and trabecular; (2) lymphoid; (3) endotheloid, giving rise respectively to fibrosarcomas, lymphosarcomas and endothelioid sarcomas.

Symptoms and Diagnosis.—The patient may seek medical aid on account of the abdominal growth. Pain, although not a constant symptom, is usually present and may be very severe at times. The chief clinical characteristic of the condition is a rapidly growing tumor in the left side of the abdomen. If the tumor is hard, nodular and irregular it is almost safe to assume that a malignant condition exists (Council[1]). There is no sign or symptom on which absolute reliance can be placed, so that in order to arrive at a diagnosis we may be compelled to exclude other forms of splenomegaly. The first two cases of sarcoma of the spleen were recorded by Weichselbaum,[2] in 1881. Up to 1912 Council collected 37 cases; 17 of these patients were operated on by enucleation and 16 by splenectomy. Out of the 17 enucleated, 1 patient died seven days after operation; of the 16 splenectomies, 1 patient was lost track of, 3 died following operation, 5 died of recurrence at indefinite periods, 7 were well when reported at times varying from four months to six and one-half years after operation. In view of the great malignancy of the sarcomas in general there must remain a doubt as to the diagnosis in some of these cases.

Cysts.—Cysts of the spleen may be divided into: (1) dermoid; (2) echinococcus; (3) non-parasitic.

1. *Dermoid cysts* are exceedingly rare. The only case found in the literature was reported by Andral[3] in 1830.

2. *Echinococcus cysts* are not uncommon in countries where hydatid disease prevails. According to Thomas the spleen is affected in 2 per cent. of all cases of hydatid disease. He collected 88 cases of hydatid cysts of the spleen and in 45 of these the spleen alone was involved. It was thought that the embryos reach the spleen by boring their way directly through the intestines or the gastric wall where those organs are in contact with the spleen. In hydatid disease of the liver the embryos have been found in the portal circulation and doubtless enter the liver by the portal route. It is quite improbable that the spleen is attacked in this way as it would be necessary for the embryos to travel against the blood stream. The cysts may be situated anywhere in the organ; they may be unilocular or multilocular, single or multiple; they contain a thin, pale fluid with a specific gravity of 1004 to 1010 which abounds in organic salts and usually contains scolices of the parasite.

3. Fowler[4] gives a very careful detailed account of all reported cases of *non-parasitic cysts* up to 1912. He is of the opinion that the

[1] Ann Surg., 1912, lvi, 915–924.
[2] Virchows Arch., 1881, lxxxv, 562. Quoted in Keen's Surgery, Philadelphia, 1908, iii, 1093.
[3] Quoted by Osler and MacCrae, Modern Medicine, 1915, iv, 953.
[4] Ann. Surg., 1913, lvii, 658–690.

classifications suggested to the present time are unsatisfactory, on account of our lack of knowledge concerning their origin. Usually they are subdivided into: (*a*) hemorrhagic; (*b*) serous; (*c*) lymphatic cysts.

(*a*) The hemorrhagic cyst is the most common variety and may be due to one of several causes. From a study of the reported cases it would appear that trauma is one of the most frequent factors. In some cases there is evidence of the occurrence of spontaneous rupture of diseased and degenerated bloodvessels while in other cases hemorrhage takes place into other varieties of cysts. Congestion of the spleen as in malaria and typhoid fever may result in spontaneous rupture of the bloodvessels and lead to cyst formation. These enlarged spleens are also more liable to injury. The contents depend on the age and the size of the cyst; at first they consist of fresh blood. At operation, however, rarely is there evidence of recent or active hemorrhage. Depending on the degree of alteration, the contents may be thin, pale, and liquid or remain thick and black. Old cysts usually contain hematoidin and cholesterin crystals.

(*b*) Serous cysts of the large unilocular type may be said to arise secondarily from hemorrhagic cysts. The contents, at first bloody, become thin and have a clear, pale straw color. Boettcher claims that small, deep, multilocular cysts are due to degeneration of small areas of splenic tissue that result from amyloid changes in the bloodvessels. Bencke considers small multilocular serous surface cysts as due to infoliation of peritoneal endothelium resulting from the traumatic rupture of the splenic capsule. He claims that splenic tissue protrudes through the small rupture and becomes snared off between neighboring areas of parenchyma forming cystic cavities. Renggli believes that certain cysts are formed as the result of fusion of proliferated areas of endothelium following inflammatory processes. The fused endothelium becomes snared off at different points and later becomes subject to cyst formation.

(*c*) Lymphatic cysts probably arise from dilatation of the lymph spaces. Fink suggests this origin and in some varieties it would seem to be a reasonable explanation, especially where an extensive multilocular cyst formation exists. The liquid in lymphatic cysts has a high specific gravity with a tendency to coagulation.

Symptoms.—From the clinical standpoint the most important varieties are of the hemorrhagic and serous type. The other varieties are usually accidental postmortem findings as they do not produce symptoms. No specific changes or symptoms take place as the result of destruction of splenic tissue. The most important and constant symptom is pain. This is usually located in the left hypochondrium but it may be referred to the epigastrium. As the result of peritoneal irritation the pain may be acute, causing nausea and vomiting; usually, however, it is of a dragging character. Sometimes the patient accidentally discovers a tumor which may be symptomless. There may be digestive disturbance due to dragging or pressure of the

stomach or intestines. There may be dyspnea as the result of upward pressure. The tumor is usually located in the left hypochondrium and is of slow growth. Cysts of large size may reach below the umbilicus; they may be smooth or irregular, soft and doughy or tense and elastic.

Diagnosis.—As has been pointed out, the most decisive symptom is the discovery of a cystic tumor in the left hypochondrium which is movable and whose dulness is continuous with that of the spleen. A careful history must be taken as to trauma, the site where the tumor was first noticed, rapidity of growth, and the site and character of the pain. In most cases a more refined diagnosis than splenic enlargement or abdominal cyst cannot be made until the abdomen is opened. Enlargements of the kidney and cysts of the pancreas, the left lobe of the liver, omentum and mesentery must be differentiated from cyst of the spleen. Renal conditions are usually excluded by the use of colloidal silver and the roentgen ray together with ureteral catheterization. If the cyst of the spleen is displaced, a diagnosis may be impossible and under such conditions has been mistaken even for ovarian cyst.

Treatment.—Within recent years the majority, if not all, cases have been treated by splenectomy. Up to 1912 Fowler[1] had collected 27 cases treated in this way. In 2 the results are not reported; 1 died and 24 recovered. Other methods such as puncture, incision and drainage and excision have been employed. Where extensive adhesions exist and in some cases of parasitic cyst, incision and drainage may be the operation of choice. One may safely say that splenectomy is, as a rule, the operation to be preferred and is probably attended by the best results.

In case the surgeon desires to treat a cyst of the spleen by puncture and drainage, it is important to guard against the spilling of any fluid contained in the cyst into the peritoneal cavity for fear of producing secondary infection in case the cyst should prove to be due to echinococcus, a complication which has been reported by several surgeons. In case of any doubt, the fluid should at once be examined microscopically to determine the presence of hooklets and scolices. In case these are present, the lining of the cyst should be peeled out in order to remove all of the scolices attached to the inner surface. The remaining cavity should be tamponed with gauze and permitted to contract and heal from the bottom.

Angioma.—Angioma of the spleen is a rare condition and is often accompanied by angiomatous involvement of other organs. The liver is frequently affected, in some instances to a greater extent than the spleen. Dowd[2] reports a case of cavernous angioma of the spleen and has collected 12 other cases which, in his opinion, belong to this group. He states that certain cases may be recorded under different headings. The condition is liable to be confused with hemorrhagic

[1] Ann. Surg., 1913, lvii, 658–690.

[2] Ann. Surg., 1915, lxii, 177–181.

cyst. Two of the cases are classified as sarcomatous angiomas because of the presence of areas of cells similar to the spindle cells found in sarcoma. In Dowd's own case and in 5 of the collected cases, other organs than the spleen were involved. The liver was affected in 4 patients in 1 of whom there were eighty-five angiomatous spots on the skin. The omentum was affected in one patient, liver, stomach and lungs in one. Three of the remaining 7 patients recovered from their splenectomies and whether or not the disease existed in other organs is uncertain. Four cases were reported from autopsies, nothing being said of other organs involved in the process.

As will be readily understood, diagnosis of angioma of the spleen is very difficult and in most cases impossible. Patients usually complain of pain in the splenic region, associated with tumor formation. Pain may be constant or in acute attacks. In 1 case pulsation could be felt on the tumor and on auscultation a murmur could be heard.

Exploratory operation will usually be necessary to establish a diagnosis and to ascertain the extent of the process. If the angiomatous condition involves other organs than the spleen, nothing can be done for the patient. If, however, the spleen alone is affected, splenectomy should be performed.

Abscess.—Abscess of the spleen may be primary or secondary. Both conditions are rare; in fact some writers question the occurrence of primary abscess. Moynihan[1] says the occurrence of primary abscess is a possibility, but a fanciful one, and further states that he had not discovered any indisputable evidence of its existence.

In the majority of cases secondary abscesses are the result of septic infarcts and metastatic infection carried to the spleen in the blood stream during the course of some pyogenic invasion. Emboli frequently result from septic endocarditis. Metastatic infection may be secondary to septic foci in any other part of the body but especially to those foci within the portal area. Fauntleroy[2] reports a case which was evidently secondary to acute appendicitis. Other instances of splenic abscess have been reported as occurring during the acute specific infections, especially typhoid fever and malaria. Anderson[3] draws attention to the occurrence of splenic abscess in malarial fever. He states that in 77,949 cases of malarial fever only 2 cases of abscess of the spleen were diagnosed during life. In available postmortem records he found 5 cases only of splenic abscess. In 3 of these 5 cases there was evidence that the abscess was due to infarction of the organ. Secondary infection of a hydatid cyst or a hematoma may result in abscess formation. Lastly, infection of the spleen resulting in abscess may be due to the direct extension of inflammatory processes from adjacent organs; for example, as a sequence of perforating gastric ulcer or thoracic empyema.

Pathology.—The spleen is usually greatly enlarged and easily palpable; in some instances, however, it is only slightly increased in

[1] Keen's Surgery, Philadelphia, 1908, iii, 1076.
[2] Jour. Am. Med. Assn., 1911, lvi, 260–261.
[3] Lancet, 1906, ii, 1159–1160.

size and not palpable. Abscess formation may be single or multiple. In the non-embolic form it is usually single and, as a rule, not larger than a goose egg. In rare cases the abscess may attain large dimensions and the entire spleen may be replaced by an accumulation of pus. Embolic abscesses are usually small and multiple; sometimes they coalesce to form large abscess cavities. In most cases there is marked perisplenitis with extensive adhesions which tend to limit the growth of the abscess.

Symptoms and Diagnosis.—In many instances splenic abscess is a postmortem finding. There may be absolutely no symptoms indicating splenic involvement. In Fauntleroy's case splenic infection was not considered though all other probable foci were ruled out. In general, the symptoms are those of suppuration elsewhere, together with pain localized in the splenic area associated with rapid enlargement of the organ. In the embolic form the splenic symptoms may be entirely masked by the original condition, thus obscuring the diagnosis. Perisplenitis can sometimes be identified by the recognition of a friction rub. Splenic puncture as a method of diagnosis is generally regarded as a dangerous procedure, and should not be attempted.

Rupture of an abscess may take place into any of the adjacent hollow organs, which may have become adherent to the spleen or, again, the abscess may rupture into the abdominal cavity or plural cavity, causing peritonitis or empyema. On very rare occasions, the abscess may rupture externally, leading to ultimate recovery.

Prognosis.—The prognosis in splenic abscess is very bad. The recorded death-rate in reported cases varies from 70 to 80 per cent. However, in many instances the primary sepsis was in reality a sufficient cause of death.

Treatment.—If the abscess is localized in the abdominal wall it should, of course, be drained; in other cases it may be necessary to open the abdomen to establish drainage. Splenectomy in an occasional case may be the best procedure. The mortality is high, the best results being obtained where direct infection has occurred.

Tuberculosis.—Winternitz[1] states that tuberculosis of the spleen may be primary or secondary. By primary it is not meant that the spleen is the portal of entry of the organism, or even the first tissue of the body in which the disease manifests itself, but that the disease process may localize in the spleen and not only bring about various lesions but act as a focus for the dissemination of the bacilli while the original focus may have become completely healed. It is probable that in all cases of tuberculosis of the spleen other tuberculous foci exist which may or may not be active. However, in cases considered as tuberculosis of the spleen, the spleen shows the most marked and advanced lesions and after splenectomy many patients become well. Previous to 1846 when Coley reported a case of primary tuberculosis in the spleen, it was thought that all cases were secondary to

[1] Arch. Int. Med., 1912, ix, 680–697.

more advanced foci and that treatment was of no avail. Since then, however, numerous cases have been reported, a large percentage of which have been cured by splenectomy, showing that nature can successfully cope with minor lesions when the principal site of the disease is removed. Winternitz collected 51 cases; in those instances in which the liver was examined 80 per cent. showed involvement; the lymphatics were found diseased in 57 per cent. of the cases; 40 per cent. showed complications of the lungs and lesions were found elsewhere in 66 per cent. In 1 case only was the spleen alone affected and in 3 only were the spleen and liver involved. From these data we may conclude that it is possible for true primary tuberculosis of the spleen to exist; but as there is only 1 case reported in which, after a careful search, the disease was found to be confined to the spleen it must be concluded that in reality tuberculosis of the spleen is always secondary to some other focus which may or may not be healed.

Pathology.—In acute cases, the spleen is greatly enlarged; it may be firm and resistant or very soft. Numerous tubercles are scattered throughout the organ and microscopically these show extensive necrosis and are surrounded by epithelioid cells or merely by splenic pulp. In the more chronic type the spleen is firm and indurated and usually bound down by many adhesions due to perisplenitis. Tubercles varying in size are present and consist of firm yellow caseous material. Others are soft and of a grayish color. The tubercles are surrounded by epithelioid cells and giant cells. There may be marked necrosis in the center of the tubercles with absorption, resulting in cyst formation. In the chronic form there is always a marked increase of fibrous tissue, giving the organ its firm and resistant consistence.

Symptoms.—The disease is most common between the ages of twenty and forty years but may occur at any age. The onset of the disease is usually insidious and pursues a chronic course. The symptoms may be divided into three groups: acute, chronic and subacute. A small number of acute cases have been reported in which the symptoms were extremely severe and suggestive of an acute infectious process or the spleen was enlarged and the clinical course simulated that of typhoid fever. In the chronic form of the disease the patient usually consults the physician on account of tumor and pain in the splenic region. Gastric and respiratory disturbances may also be present. Other symptoms which, however, are common to many diseases are progressive weakness, loss of weight, lassitude, etc. The finding of tuberculous foci in other organs together with the above symptoms aids in the diagnosis. The roentgenologic examination of the chest may prove valuable. Giffin[1] reports a case in which splenectomy was done. At operation the spleen was found to be studded by numerous abscesses and tuberculous deposits. The history extended over a period of sixteen months and no definite evidence of tuberculosis was found elsewhere in the body before operation. The

[1] Am. Jour. Med. Sc., 1913, cxlv, 781–795.

patient died four months later, however, with evidence of disseminated tuberculosis. A postmortem was not obtained. In the cases analyzed by Winternitz no detailed account is given as to the occurrence of fever. In some cases fever is mentioned as being present while in other cases it was intermittent or of the septic type with evening exacerbation. It is probable that fever exists in every case at some time during the course of the disease. The blood findings are very inconstant. Anemia is never marked, the lowest red cell count reported being 3,200,000. In Winternitz's 51 cases the blood findings were mentioned in 26; in 6 of these the count was characteristic of polycythemia. Some observers attach great importance to the relationship between tuberculosis of the spleen and polycythemia; the relationship, however, would seem to be very indefinite. Numerous cases of polycythemia have been reported in which no tuberculous process was found in the spleen, and *vice versa*. The third group of cases is intermediate between the acute and chronic forms and the symptoms are not as intense and overwhelming as in the acute cases and not as insidious as in the chronic form.

Treatment.—Winternitz holds that tuberculosis of the spleen, whether acute or chronic, is an absolute indication for splenectomy; that by removal of the spleen 59 per cent. of patients recover; otherwise death invariably takes place. Splenectomy would seem to be indicated, however, only when the extent and activity of tuberculous lesions elsewhere are carefully considered with reference to the probable operative and postoperative mortality in the individual case. As in all other tuberculous conditions, the patient should be placed in the best hygienic surroundings.

Splenic Anemia and Banti's Disease.—The literature of surgery abounds with discussions on the spleen. Surgeons may be tempted to become overenthusiastic and to remove the spleen without due consideration. Every case with splenomegaly demands thorough study and an effort should be made to establish an exact diagnosis before surgical treatment is considered. The diseases associated with splenomegaly are apt to be confused and it is likely that many recorded cases have been placed in certain defined groups without sufficient clinical evidence. Only in recent years are we beginning to distinguish certain syndromes as clinical entities. Cases of syphilitic splenomegaly, chronic septic splenomegaly and Gaucher's disease, which were formerly classified as splenic anemia, are gradually being separted from the splenic anemia group. Cases of an indefinite nature should remain unclassified until experience has given us further knowledge of the spleen and the diseases associated with it. Splenectomy as a curative agent for splenic anemia and hemolytic jaundice has been definitely established and experienced surgeons are unanimous in their plea for the removal of the spleen as soon as a diagnosis has been made. Medical treatment has not been of permanent avail and the literature demonstrates that a majority of patients have been cured by splenectomy, while those not cured have obtained marked

benefit even in an advanced stage of the disease. Splenectomy for Gaucher's disease, chronic septic splenomegaly and certain hepatic cirrhoses has not been followed by results that are clearly satisfactory; however, they are encouraging and, as medical treatment has failed to produce satisfactory and lasting benefit, splenectomy in the latter conditions would seem to be justifiable in certain cases. In primary pernicious anemia, splenectomy has been followed by variable results. At present we can at least say that splenectomy has produced in a certain number of cases marked temporary benefit when medical treatment has failed. In recent years the mortality of splenectomy has been steadily decreasing. If surgical treatment be resorted to early, before the patient has become markedly debilitated, the operation can be performed with little risk to the patient. Even patients that are anemic and weak withstand the operation remarkably well. When profound anemia exists, resistance may be materially improved and the risks of operation lessened by blood transfusion.

The relationship between splenomegaly and the secondary type of anemia with leukopenia was first demonstrated by Gretzel[1] in 1866. Since then several types have been described and reasonably well defined from a clinical standpoint.

Banti,[2] in 1894, described a disease, the salient characteristics of which were splenomegaly, secondary anemia and cirrhotic liver with ascites. This condition we now know to be the final stage of true splenic anemia; in other words, splenic anemia and Banti's disease are one and the same clinical entity. Splenic anemia may be defined as a chronic affection characterized by a progressive or remittent enlargement of the spleen for which as yet no cause has been assigned. An anemia of the secondary type is present, usually accompanied by leukopenia, a tendency to hemorrhage—especially from the stomach—and in many cases a terminal stage with cirrhosis of the liver and often ascites. No case should be classified as splenic anemia in which, after careful clinical study, the disease does not seem to be primary in the spleen, or in which the spleen, on pathological examination, does not show chronic, hypertrophic fibrosis. Chronic septic splenomegaly, syphilitic splenomegaly, cirrhosis of the liver, and splenic anemia of infancy must be differentiated clinically, and Gaucher's disease, lymphoma, lymphosarcoma and the various types of tumor must be differentiated pathologically.

Etiology.—The primary factor in the production of splenic anemia is unknown. Many different theories have been advanced, the majority of which seem to hold that the spleen is the instrument through which some unknown agent produces the disease.

Cholelithiasis has occasionally occurred with splenic anemia and Giffin states that the etiological relationship of gall-bladder disease may be important both by reason of the possibility of infection and also through some influence of circulation in the closely related organs of the upper abdomen.

[1] Berl. klin. Wchnschr., 1866.

[2] La Sperimentale, 1894, Sez. Biol., 48.

Yates, Bunting and Kristjanson[1] obtained pure cultures of a diphtheroid organism from the spleens of 2 cases of splenic anemia. They are of the opinion that certain cases of splenic anemia may be due to these organisms. After citing some clinical points which indicate a parallelism between Hodgkin's disease and splenic anemia they suggest that splenic anemia might be a Hodgkin's disease of the spleen. (They believe their findings are significant, especially in view of Gibbon's[2] work in which he found a Gram-staining streptotrichal organism in 6 cases of splenomegaly.)

Syphilis, malaria, passive congestion of the spleen as a result of obstruction to the portal circulation, and thrombosis of the splenic or portal veins have all been considered and no doubt are responsible for certain cases of splenomegaly. These should, however, be placed in a group separate from the splenic anemia described by Banti, Osler[3] and others.

Various writers have reported two or more cases of splenic anemia occurring in one family. However, that heredity should be considered a causative factor seems questionable. Osler and Giffin, who have both reported large series of cases, did not find any evidence of hereditary influence.

Pathological findings have not yet aided us in our search for an etiological factor in splenic anemia. The picture most commonly presented would seem to indicate that the changes in the spleen are due to some form of chronic poisoning.

That the spleen is either the primary cause of splenic anemia or the chief agent through which some unknown factor exerts its influence seems evident in view of the fact that splenomegaly always precedes anemia and cirrhosis of the liver and that splenectomy is followed by cure.

Pathology.—Pathologists usually find a diffuse overgrowth of all the tissue elements, particularly the connective tissue. This is accompanied by sclerosis and atrophy of the pulp and Malpighian bodies. Wilson[4] states that 13 of his 18 cases showed a general hyperplasia of all the tissues, sometimes one or more predominating. These 13 correspond to those chosen from Giffin's[5] series as representing typical splenic anemia. In the majority, however, a marked fibrosis was a constant picture. In the advanced stage of splenic anemia he found a great tendency to fibrosis together with dilatation of the capillaries and arteriosclerosis.

Incidence.—The disease usually comes under observation during the middle period of life. It may, however, occur at both extremes. In Giffin's series, the average age was forty years, the youngest being twenty-two and the oldest fifty years. Recently we have performed splenectomy on a child, aged two and a half years, that clinically

[1] Jour. Am. Med. Assn., 1914, lxiii, 2225. [2] Quart. Jour. Med., 1914, vii, 153.
[3] British Med. Jour., 1908, ii, 1151–1158.
[4] Surg., Gynec. and Obst., 1913, xvi, 240–251.
[5] Am. Jour. Med. Sc., 1913, cxlv, 781–795. Only thirteen of Giffin's cases were later found to be typical of splenic anemia as far as could be determined clinically and pathologically.

and pathologically conformed to the picture of splenic anemia. Both sexes are equally affected.

Symptoms.—One of the most extraordinary features of this disease is its remarkable chronicity. Histories have been obtained where there was definite and sufficient evidence that the disease had existed for more than twenty years. An enlarged spleen may be discovered and yet the patient have enjoyed reasonably good health with the exception of an occasional hemorrhage from which the patient slowly recovers. In other cases evidences of the disease have been present a comparatively short time. In Giffin's series, the splenic tumor had been noted in 5 patients less than one year previous to operation, irrespective of the age of the patient. In a majority of instances splenomegaly had existed previous to the onset of the anemia. Giffin was satisfied that 9 out of 13 had been aware of the abdominal tumor previous to the occurrence of symptoms of anemia and it is quite probable that the spleen had been enlarged but unrecognized for a longer period. In no cases did anemia definitely occur before splenomegaly. The enormous dimensions the spleen usually attains is a striking feature. Of the 13 cases showing chronic splenitis chosen from Giffin's series, Wilson reports the largest spleen as weighing 1670 grams, the smallest, as weighing 425 grams, the average weight being 1089 grams. Other observers also direct attention to the marked degree of splenic enlargement. The largest spleens with the possible exception of leukemia and Gaucher's disease are found in splenic anemia. The spleen, as a rule, lies within the limits of the left half of the abdominal cavity. Cases have been reported, however, in which it extended beyond the midline and even occupied the right iliac fossa. The abdomen may be enormously distended. Pain in the region of the tumor is a common complaint, occasionally occurring in acute attacks. Perisplenitis with adhesions is usually found at operation and no doubt accounts for the occurrence of pain. The position of the tumor, its contour and edge, and presence of notches usually determine the nature of the growth. There are, however, instances in which special methods of diagnosis are necessary to a definite conclusion. These will be discussed later.

Hematemesis.—Hematemesis is a frequent occurrence in splenic anemia. Sometimes the bleeding is so excessive as to cause death. Occasional instances of hemorrhage from the bowel, epistaxis, bleeding from the gums, and retinal hemorrhage have been reported. In a majority of cases, however, the bleeding is gastric in origin. It may recur over a period of years, often with long intervals. In Osler's series of 15 patients, 8 had attacks of hematemesis. The cause of hemorrhage would seem to be due to mechanical influences related to the enlarged spleen and not necessarily to cirrhosis of the liver. At operation some of the patients who had had severe hemorrhages were found to have normal livers. Congestion and oozing from the gastric mucosa, gastric erosions, rupture of varicose veins of the esophagus, are all cited as causes.

Anemia.—There is no pathognomonic change in the blood picture. An anemia of the secondary type is present. In Giffin's series 11 cases had hemoglobin below 75 per cent., 1 of 20 per cent. and another of 35 per cent.; the average was 57 per cent. Osler draws attention to the low percentage of hemoglobin and states that it is rather more striking than in other secondary anemias. The average in 13 of his cases was 47 per cent. with extremes of 25 and 75 per cent. The reduction in erythrocytes is usually moderate, the average in Osler's series being 3,425,000. The average in 12 of Giffin's cases was 3,904,166, but in 2 cases the blood count was over 5,000,000 at time of observation. In 1 case the red blood cells were reduced to 1,200,000. With marked anemia, an occasional normoblast and megaloblast may be found. Slight poikilocytosis and polychromophilia may also be present. In uncomplicated cases the leukocytes are, as a rule, reduced in number. After a hemorrhage, however, the usual leukocytosis may be present. The average count is usually between 3000 and 5000. A differential count of the white cells shows no characteristic change. As in other anemias, the patient usually complains of lack of energy and ambition, weakness and debility.

A brownish yellow pigmentation of the skin is a common occurrence and has been noted by most observers. It is usually diffuse in character, rarely intense. Jaundice has not been noted as occurring in any of the cases examined at the Mayo Clinic. In the literature, however, we find occasional reports of jaundice having been present with and without cirrhosis of the liver. It is possible that these cases were not splenic anemia but rather belong to the hemolytic group.

Ascites may occur as a terminal condition and is usually associated with cirrhosis of the liver. One of Osler's patients showed no cirrhosis at postmortem although there had been recurring attacks of ascites. In Giffin's series an operative diagnosis of cirrhosis of the liver was made in 5 cases. Three of these patients had reached the ascitic state of the disease. None of his cases showed abdominal fluid without evidence of hepatic change at operation. It is possible that the marked anemia and the effect of the large spleen on the circulation may account in some instances for the ascites.

Digestive Disturbances.—During the course of the disease and especially in the later stages, the patients may suffer from loss of appetite, nausea and sometimes vomiting and diarrhea.

Cardiac Symptoms.—As in other forms of anemia, there may be troublesome cardiac symptoms such as shortness of breath and palpitation.

Renal Complications.—Rarely is there evidence of renal complication other than the presence of a trace of albumin in the urine.

Fever.—It would seem that the majority of cases run a normal or nearly normal temperature throughout the course of the disease. Cases with fever have been reported, especially in the terminal stage. It is usually safe to assume that patients with fever are either suffering from intercurrent infection or do not belong to the splenic anemia group.

Diagnosis.—In typical cases presenting long progressive histories of splenic enlargement and hemorrhages, and showing an anemia of the secondary type without leukocytosis, we are usually able to arrive at a definite diagnosis. In many instances, however, there is some doubt as to the exact condition. Frequently the mistakes of experienced clinicians are revealed at operation or postmortem. The most important diseases which add to the difficulties of diagnosis are as follows:

Splenomegaly Associated with Syphilis and Accompanied by Secondary Anemia.—That this condition has been confused with splenic anemia has been the experience of those interested in diseases of the spleen. It is, therefore, necessary that all patients with enlarged spleens should have Wassermann tests in order so far as possible to exclude syphilis. The history should also be reviewed very carefully for evidence of infection. Splenectomy has been done at the Mayo Clinic in 3 cases of this character, in which the symptoms simulated splenic anemia and Banti's disease. It is, of course, possible for syphilis and splenic anemia to exist in the same patient. It seems certain, however, that a condition closely simulating splenic anemia is produced by syphilis, thus a careful review of the history for specific infection and Wassermann tests are imperative.

A Group of Cases which Simulate Splenic Anemia but Present a History and Signs of Subacute or Chronic Infection.—In this group a history of chronic sepsis can be obtained. In some instances the onset of the illness is characterized by symptoms of acute infection followed by a history of chronic or subacute infection which may extend over a period of years. There may be evidence of cardiac or renal disease, streptococcal invasion, or the infection may be of pelvic origin. Blood cultures and tests for syphilis, malaria and tuberculosis will be negative. Attacks may last two or three months and may occur at intervals of several months. Between attacks the splenic tumor may be greatly reduced in size. Leukopenia is usually present save at the time of exacerbations. Four such patients have been operated on at the Mayo Clinic. This group should be clearly separated from splenic anemia. On account of the widespread infection in some of these cases, splenectomy will not be followed by entirely satisfactory results and each case should be carefully considered before surgery is contemplated.

Splenomegaly without Anemia.—Osler calls attention to this condition which may exist for years without apparent injury to health. The spleen is not as large as that of splenic anemia. During routine examinations we have frequently found moderately large spleens, especially in inhabitants of southern Europe. Such conditions are most likely to be mistaken for splenic anemia in the early stages. It is likely, indeed, that some of these cases are in reality incipient splenic anemia. A definite diagnosis, however, cannot be made.

Pernicious Anemia.—Only occasionally does the spleen in pernicious anemia become so large as to suggest splenic anemia. If at the same time there is an atypical blood count, a diagnosis may not be

possible. Such circumstances, however, are very rare. The blood picture will usually guide us to a proper conclusion.

Portal Cirrhosis Associated with Splenomegaly.—In some instances it is very difficult to differentiate this condition from splenic anemia. In cirrhosis the change in the liver precedes that in the spleen, while the reverse holds true in splenic anemia. With cirrhosis we usually find a much smaller spleen and the anemia is not so marked. Ascites as a result of portal obstruction is an early feature. Very often there is an evident etiological factor.

Biliary Cirrhosis of the Infectious Type.—Biliary cirrhosis is not an exceedingly rare sequence in chronic infectious processes of the upper abdomen. Chronic jaundice is, however, a most prominent sign in biliary cirrhosis, while it rarely if ever occurs in splenic anemia. The signs of portal obstruction appear late.

Biliary Cirrhosis of the Hanot Type.—A primary hematogenous biliary cirrhosis seems to occur very rarely. The signs of biliary cirrhosis of infectious origin will be present without, however, a demonstrable infectious focus.

Gaucher's Disease.—Clinically Gaucher's disease can be definitely differentiated from splenic anemia only by demonstrating the characteristic endothelioid cells on splenic puncture or in an excised lymphatic gland. Splenic puncture will not be frequently attempted on account of danger from hemorrhage. The recurrence of Gaucher's disease in two or more members of the same family and its frequent appearance in childhood are noteworthy. The differentiation from splenic anemia is, however, essentially a pathological one.

Lymphoma and Lymphosarcoma.—Lymphoma and lymphosarcoma may be rarely suspected upon clinical examination. The superficial gands and the chest are especially apt to be sites of metastasis.

Hemolytic Jaundice.—Cases of hemolytic jaundice have frequently been diagnosed splenic anemia. They may be seen when jaundice is absent and a very careful inquiry is necessary to elicit information concerning jaundice when its degree has been slight. In congenital cases the history of recurrent anemia and jaundice can be traced to infancy. An increased fragility of the erythrocytes and the presence of urobilin in the urine are most important clinical evidence.

Diseases of the Left Kidney.—Tumors of the left kidney have often been mistaken for large spleens and *vice versa*. If there is the least doubt as to the nature of the tumor a cystoscopic examination together with a pyelogram will usually eliminate the difficulty.

Treatment.—As in other types of anemia, temporary improvement is usually obtained in splenic anemia by drug therapy. The arsenic and iron compounds are chiefly employed. Blood transfusion has proved efficacious. By these means, together with fresh air and a wholesome and liberal diet, the patients are usually benefited a great deal. Unfortunately, however, improvement is only temporary. Symptoms are certain to return and the patients ultimately die of the disease or some intercurrent affection.

From a study of the literature and especially of records embracing a comparatively large group of cases, one is justified in concluding that splenectomy is the rational method of treatment. In the early stages of the disease, splenectomy should be attended with the best results; but even when changes in the liver have occurred, the patient may return to apparently normal health. Several patients have been closely observed for as long as twelve years after operation without recurrence of the original symptoms. Patients presenting very marked changes in the liver and ascites may derive benefit from the Talma operation in conjunction with splenectomy.

Of the 13 definite splenic anemia cases in Giffin's group, 8 are in excellent health for periods varying from six months to seven years. In this group 3 cases had reached the Banti stage, 1 with and 2 without ascites. These cases are in excellent health, 1 as long as five years after operation.

The mortality due to splenectomy in splenic anemia seems to be decreasing year by year. Rodman[1] states that up to 1908 the collected cases showed a death-rate of 17 per cent. From 1908 to 1912 the percentage fell to 10.125 per cent. These statistics represent for the most part single cases by many operators. Giffin[2] reports 27 splenectomies for splenic anemia with 3 operative deaths. Hemorrhage was the cause of postoperative death in 2 instances, in 1 case occurring one year after operation, in the other five and a half years after operation. In 3 other instances hemorrhages occurred two or three times after operation but the patients are at present in good health.

Adult Type of Splenic Anemia in Children.—Although much confusion exists in literature regarding the anemias associated with splenomegaly in children, it is concluded by observers who have carefully studied the subject that a condition conforming in every detail to the splenic anemia of adults, occurs in children. Very often the adult form of splenic anemia in children is grouped and confused with the splenomegaly of rickets or inherited syphilis. A study of the literature indicates, however, that there are occasional instances of anemia and splenomegaly with apparently no relation to rickets or inherited syphilis, which from a clinical standpoint are similar to splenic anemia as it occurs in adults. Indeed, there is evidence in some instances of the adult type of splenic anemia that the disease dated from childhood. Splenic anemia of the adult type not infrequently occurs during the first decade. Rarely, however, has splenectomy been performed in patients of this age. Giffin records a case of splenectomy for splenic anemia of the adult type in a girl, aged two and a half years (operated on by Balfour[3]), and states that he is able to find reports of 5 other cases in literature in which splenectomy was done. One patient was well eighteen years after splenectomy, one in excellent condition nine months after operation, and the third was greatly improved two

[1] Rodman, J., Stewart and Williard, De Forest, P.: Ann. Surg., 1913, lviii, 601–615.
[2] Ann. Surg., 1915, lxii, 166–171.
[3] Surgery of the Spleen, Internat. Abst. Surg., 1918, xxvi, 1–15.

months after operation. The remaining 2 patients died, one four days and the other six weeks after the spleen was removed.

It has already been indicated that the adult type of splenic anemia as it occurs in childhood has been confused with other forms of splenomegaly. It is necessary, therefore, that each case be thoroughly studied and that rickets, inherited syphilis, and gastro-intestinal disorders be excluded as primary etiological factors. Gaucher's disease, lymphosarcoma, septic splenomegaly, particularly as associated with endocarditis, hemolytic jaundice and the splenic anemia of infancy (von Jaksch's disease) are also to be included in the differential diagnosis.

Splenic Anemia of Infancy or von Jaksch's Disease.—In dealing with diseases of the blood in the young, it must be remembered that the normal blood of early childhood and particularly of infants under two years of age, differs from the normal blood of the adult. The leukocyte count may reach 14,000 under normal conditions. This moderate leukocytosis is essentially a lymphocytosis, the normal lymphocyte percentage usually reaching 40 or 50. It is also generally recognized that the blood of infants reacts differently than the blood of adults to various toxic agents. A lower red cell count with a consequent higher color index, the presence of normoblasts, and occasionally a few megaloblasts, and a leukocytosis with the occurrence of eosinophiles and myelocytes are often observed in the anemias of infancy. Shaw[1] states that secondary anemias associated with splenomegaly in children are mostly the result of inherited syphilis, rickets and digestive and metabolic disturbances. Discussing these different groups, he points out that in congenital syphilis the blood picture may resemble that of pernicious anemia, splenic anemia or even leukemia. In rickets the blood picture of splenic anemia or leukemia may be present. All the anemias may show an atypical blood picture at times, so that having to rely mainly on the blood count for a diagnosis in certain conditions, it is not surprising that diseases associated with splenomegaly in children are confused.

Literature concerning the anemias of childhood is very abundant and shows that in many instances, rickets, inherited syphilis, and gastro-intestinal disorders are probable etiological factors. It is agreed, however, by many authorities, that there is a certain group of cases occurring in infancy which on account of the marked splenomegaly, severe secondary anemia, evidence of blood destruction and with a more or less characteristic blood picture, should, for the present at least, be considered as a separate clinical entity.

Splenic anemia of infancy or von Jaksch's disease was referred to by Gretzel in 1846. In 1889 von Jaksch discussed it in greater detail and separated it from other conditions. It is evident from the literature that it is a disease of infancy and early childhood. No cases are reported in which the patient was more than two and a half years of

[1] Lancet, 1904, ii, 1560–1562.

age. Giffin concludes that there is a close relationship between the splenic anemia of childhood and the splenic anemia of infancy and the blood picture in the latter indicates a reaction of toxins which is peculiar to the hemopoietic system of the infant. The disease closely resembles the adult form of splenic anemia of children in some of its clinical features as well as possessing certain distinctive differences. It is a chronic disease with a greatly enlarged spleen, hemoglobin and reds are reduced and evidently good results are procured by splenectomy. In contradistinction to the adult type of splenic anemia, there is a marked leukocytosis. The increase in lymphocytes is usually most prominent. The number of leukocytes varies from 10,000 to 100,000. In the splenic anemia of infancy, blood destruction is more pronounced than in the splenic anemia of adults. The hemoglobin is greatly reduced, sometimes as low as 25 per cent. The red cells are always diminished and vary in size and shape. Normoblasts are usually present and megaloblasts may be numerous. In the majority of instances, the liver does not seem to be affected; it may, however, be enlarged. Only 4 cases are reported in which splenectomy has been performed; 1 respectively by Fowler,[1] Graff,[2] Wolff,[3] and Pool.[4] Three of these patients were apparently restored to good health by the operation. Fowler's case showed marked immediate improvement and the other 2 were well, Graff's patient nine months and Wolff's three years after splenectomy. Pool's case was a boy baby of nine months, who although very delicate and suffering a great deal from nutritional disturbance, showed considerable improvement immediately after operation.

Large Cell Splenomegalia or Gaucher's Disease.—The pathological picture of the spleen in this condition was first described by Gaucher,[5] in 1882. The disease is not of common occurrence. In an extensive review of the literature, Brill and Mandelbaum[6] collected only 14 cases. These have all been proved to be Gaucher's disease by histological examination. Of 207 splenectomies performed at the Mayo Clinic from April 1, 1904, to January 1, 1919, only 3 cases belong to this group, and 2 of these have since been questioned. The disease was formerly classified with splenic anemia, and even at the present time is frequently referred to as Gaucher's type of splenic anemia. The histological picture of Gaucher's disease is different from that of splenic anemia. Clinically, however, the two diseases are difficult to differentiate.

Etiology.—As in other diseases attended by splenomegaly, many theories have been advanced in an effort to explain the nature and origin of Gaucher's disease. When first described by Gaucher, it was

[1] New York State Jour. Med., 1914, xiv, 435–437.
[2] Verhandl. d. deutsch. Gesellsch. f. Chir., 1908, xxxvii, 248–253.
[3] Deutsch. med. Wchnschr., 1906, ii, 2051–2053.
[4] Ann. Surg., 1915, lxi, 349–350.
[5] De l'épithélioma primitif de la rate, hypertrophie, idiopathique de la rate sans leucémia, Paris, 1882, p. 31.
[6] Am. Jour. Med. Sc., 1913, cxlvi, 803–883.

thought to be a malignant disease of the spleen. This opinion may be discarded, however, in consideration of the clinical course and the long duration of the disease. Theories analogous to those cited as the cause of splenic anemia have been advanced. The histological picture in Gaucher's disease may be the result of a peculiar reaction of the constituent tissues of the spleen to an unknown toxin. The fact that the liver, lymphatic glands and bone marrow are also affected must not be overlooked.

Pathology.—The organs affected in Gaucher's disease are the spleen, liver, lymphatic glands and bone marrow. The histological picture of these organs is characteristic and distinctive in the majority of instances so that, pathologically, the disease can usually be separated from other forms of splenomegaly. The substance of the spleen is usually firm and resistant. On cut section, numerous white areas are seen which extend deeply into the substance of the organ. The remainder of the surface has the appearance of normal spleen. The microscopic picture of the white areas is very different from the parts that resemble normal splenic structure. The latter consist mainly of large spaces which vary greatly in shape and are more or less filled with large, brightly-staining cells. The walls of the spaces are composed of fine connective-tissue fibrils, but where the cells are thickest there is a network of small capillaries, the endothelium of which consists of cells having small, round deeply-staining nuclei and resembling lymphoid cells. The characteristic feature is the presence of large round or oval cells in the spaces. These cells may lie free in the cavities of the spaces, or may be connected with their walls. When the cells are present in large numbers, they vary greatly in shape as a result of compression. The nucleus is small in comparison with the size of the cell and varies markedly in form. Many cells contain from two to four nuclei. The staining capacity of both the cells and the nuclei varies greatly; some stain deeply, while others take a faint stain. The spaces may be packed with these characteristic cells or there may be only a few cells present, the remainder of the space being filled with blood. Bovaird[1] claims that a study of the condition shows the spaces to be the pulp spaces of the spleen and that the cells are derived from their walls. The normal pulp cells have disappeared, but the Malpighian bodies remain unchanged. Sections from the white areas consist of dense connective tissue. The large cells just described are absent.

On microscopic examination of the lymph nodes, the normal cells of the medulla have entirely disappeared in areas and the transformed structure consists of a fine reticular network. In the irregular spaces of this network lie large round or polygonal cells whose nuclei are of fair size, round, oval or irregular and faintly staining. Each follicle is surrounded by a deposit of rather dark pigment. The liver, also, presents interesting changes. In many of the areas of perilobular

[1] Am. Jour. Med. Sc., 1900, cxx, 377–402.

connective tissue a picture similar to that of the lymph nodes is present. The capillaries contain pigment similar to that in the lymphatic glands. The liver cells and ducts are normal.

Characteristic large cells are found also in the bone marrow. They may be present singly or in large groups. Bovaird gives a clear description of the pathology of this disease and definitely proves that the disease is not malignant in nature.

Incidence.—The disease usually occurs in early life. In the majority of the reported cases, the patients are under the age of twelve; the youngest was one year and oldest thirty-seven years of age. The condition may exist for a long time without the patient's knowledge, so that in many instances no definite information can be obtained as to the onset. It is probable, therefore, that those cases reported as being seen in early adult life may have existed since childhood.

Sex.—Women are affected more often than men. In the 14 cases collected from the literature, there were only 2 males.

Familial Occurrence.—Frequently more than one member of the family are affected. In the cases definitely proved to be Gaucher's disease, there seems to be no hereditary tendency.

Symptoms.—Gaucher's disease is insidious in onset and runs a chronic course. The condition may exist for years, the patient evidently enjoying normal health and able to perform daily duties. One case is reported in which the condition had existed thirty-six years after the detection of the disease. The average duration of the disease in all reported cases where death was not the result of splenectomy was nineteen and three-tenths years. As a rule, death results from some intercurrent affection. Cases have been discovered accidentally during the course of routine examination, the patient having sought medical aid on account of some other disease. While there are no individual symptoms pathognomonic of the disease, there seems to be a definite association of certain symptoms in some instances sufficient to enable one, clinically, to diagnose its presence.

Splenic Enlargement.—This is one of the most characteristic features of Gaucher's disease and occurs in every case. The spleen usually attains great dimensions, even exceeding that of splenic anemia. In 1 case the weight was 7400 grams, and the average weight in 13 authentic cases was 3600 grams (Mandelbaum). Notwithstanding the presence of this greatly hypertrophied organ, it is unusual for the patient to complain of pain or other discomfort. During the late stages, however, pain may occur at intervals and sometimes in severe attacks. The size of the spleen depends on the duration of the disease. In long-standing cases the abdomen protrudes on the left side to a degree dependent on the size of the spleen.

Liver.—Changes in the liver cannot be determined clinically until the disease has become well developed. The spleen is always enlarged previous to the onset of hypertrophy of the liver. The liver then slowly and gradually increases in size and, in the late stage of the disease, may reach below the umbilicus. The increase in size in

both spleen and liver is, for the most part, due to the presence of immense numbers of the characteristic large cells to which we have already referred. Notwithstanding this marked enlargement of the liver, ascites very rarely occurs and in this respect Gaucher's disease differs from splenic anemia. Jaundice probably is never present, but there is a peculiar discoloration of the skin (to be mentioned later) which may be mistaken for jaundice.

Lymphatic Glands.—Lymphatic glands, as a rule, are not palpable. A few cases have been reported in which small, shotty glands were found in the axillary regions.

Blood.—Severe secondary anemia very rarely occurs in Gaucher's disease. The disease may exist many years and very little change take place either in the hemoglobin or in the erythrocytes. In the late stages a severe secondary anemia may develop. The size, shape and contour of the red cells are retained. Occasionally a normoblast is present; megaloblasts have never been found. In most instances there is marked leukopenia. As few as 500 leukocytes in one instance have been reported. This decrease in leukocytes takes place early and exists throughout the disease. There is nothing characteristic in the differential white count.

Hemorrhages.—As has been noted in splenic anemia, hemorrhages are usually gastric in origin, whereas in Gaucher's disease hemorrhage is most liable to take place from the mucous surface. Epistaxis, together with oozing from the gums, is of frequent occurrence. Bleeding from the intestines has also been observed.

Skin.—Early in the disease the areas of the skin exposed to the light become discolored and, as the disease progresses, discoloration becomes more intense and is of a brownish-yellow tinge. Ecchymosis in the skin due to a slight trauma is often present and the occurrence of hemorrhagic furunculosis has been recorded.

Eyes.—In a great number of the reported cases, a peculiar change has been noted in the conjunctiva. Brill and Mandelbaum emphasize this clinical finding and consider it of great importance as an aid in diagnosis and state that it was present in their 2 cases. The lesion consists of a brownish-yellow wedge-shaped thickening of the conjunctiva, the base of the wedge being limited by the cornea in contradistinction to pterygium. The process occurs early in the disease and affects the nasal side first. Later in the disease the temporal aspects shows a similar change.

Diagnosis.—We have seen that the pathology of Gaucher's disease is characteristic in the majority of cases. A few instances in which the spleen was carefully examined histologically and reported as Gaucher's disease have since been questioned. It is evident, therefore, that even a pathological diagnosis in an occasional case may be doubtful. Owing to the lack of clinical manifestations in the early stages of certain diseases associated with splenomegaly, a definite diagnosis is very often impossible. This is true of Gaucher's disease. It is a chronic disease which at the onset is symptomless and clinically no

lesions may be present save enlargement of the spleen. During the whole course of the disease, but especially in the early stages, it is most likely to be confused with splenic anemia. A diagnosis has been made from tissue obtained by puncture of the spleen. This procedure, however, is not without danger and should not be generally employed. The most satisfactory tissue can be obtained by excision of an enlarged lymphatic gland. When Gaucher's disease has existed a sufficient length of time to produce a distinctly enlarged spleen, other signs have usually developed which make a diagnosis possible. These are: Beginning enlargement of the liver, lesions of the conjunctivæ and absence of anemia and ascites. If more than one member of a family be affected, the diagnosis will be strengthened.

Treatment.—Up to the present time medical treatment has been unsatisfactory. Drug therapy consists chiefly of the iron and arsenic compounds. Roentgen-ray exposures may produce a decrease in the size of the spleen, but the improvement is only temporary. In recent years splenectomy has been practised in an effort to check the disease, but too much must not be expected because of the wide affection of the hemopoietic system. The pathological characteristics are as evident in the liver, bone marrow and lymphatic glands as in the spleen, so that the benefit following the removal of only one of the affected organs is questionable. In those instances in which splenectomy was performed there seemed to be at least temporary improvement. On account of the marked temporary improvement following removal of the spleen, the failure of drug therapy, and because of the fact that a positive clinical diagnosis usually cannot be attained, one is justified in advocating splenectomy.

Hemolytic Jaundice—Congenital and Acquired.—The relationship between congenital or familial and acquired hemolytic jaundice is an open question. Clinically, they resemble each other so closely that they may be satisfactorily studied together. As suggested by the nomenclature, the disease in the one instance dates from birth and may possess familial characteristics; in the other it is not manifest until later in life, usually during the third decennium. When the acquired form has developed, the clinical manifestations are very similar to those of the congenital form and the treatment of both is identical.

Etiology.—In recent years much experimental work has been done on the spleen and, although great confusion yet exists, the results of this work have opened up new fields of research which no doubt will ultimately lead to more definite knowledge of the etiology of the different diseases of the spleen. With regard to the cause of hemolysis, which is the principal pathological process taking place in hemolytic jaundice, the following are among the suggestions offered:

1. Widal[1] believes that the destruction of the erythrocytes takes place in the blood and that the decreased resistance of the red cells is the essential factor, splenomegaly being of secondary importance.

[1] Widal, F., Abrami, P., and Brulé, M.: Presse méd., 1907, xv, 641–644.

2. King[1] found (circulating in the blood in diseases associated with hemolysis and especially in hemolytic jaundice and pernicious anemia) an increased amount of the unsaturated fatty acids as expressed by their iodin-combining value. He is of the opinion that the presence of unsaturated fatty acids in the blood is a probable cause of hemolysis and that the spleen has some important influence in regulating and controlling these acids. This hypothesis is supported by the fact that after splenectomy the iodin-combining value of the unsaturated fatty acids becomes very low and thus accounts for the increased resistance of the red cells and the cessation of hemolysis. He also draws attention to the fact that cholesterin and the total fats are decreased in amount in hemolytic jaundice and pernicious anemia, and that after splenectomy there is marked increase in cholesterin. He states that as cholesterin possesses antihemolytic powers the resistance of the red cells after splenectomy may in part be due to the increased cholesterin value.

3. Many observers believe the spleen alone is responsible for hemolysis. If the spleen is not the sole cause of the disease, it must be granted that its presence is essential when the results of splenectomy are considered. Up to the present time the curative effect of splenectomy is one of the most important clues in our search for the cause of the disease, and it would seem fair to assume that if the pathological process is not active in the spleen itself, the presence of the spleen in some way controls the etiological factor. In view of Asher's work which demonstrated that splenic extract, although only slightly hemolytic in itself, when acting in conjunction with liver extract forms a powerful hemolytic agent, it is probable that the red blood cells are influenced in some way by the liver and spleen, thereby increasing hemolysis.

Pathology.—Unlike the spleen in splenic anemia, there is very little, if any, proliferation of connective tissue. There is a marked loss of follicles and no germinal centers. The splenic sinuses are dilated and, as Eppinger[2] reports, show a marked hyperemia. Usually there is infiltration of the splenic pulp; the endothelium shows proliferation and contains hemosiderin. The changes in the liver are very slight. There is a deposit of pigment which contains iron. This pigment is also seen in the kidneys and bone marrow. In the last mentioned organ a picture of active blood formation is present.

Symptoms.—As previously stated, the symptoms of the congenital form of the disease are similar to those of the acquired form. In the acquired form the progress of the disease is more acute, and severe crises more common. In the familial type, the affected members of the family usually suffer from a more severe type of the disease than the parent and are more likely to have acholuric crises. It has been noted, however, that the disease may exist without any

[1] Arch. Int. Med., 1914, xiv, 145–167.
[2] Berl. klin. Wchnschr., 1913, ii, 1572–1576.

inconvenience to the patient. In such instances there may be only a very slight icteric tinge of the skin and eyes and the patient may live to old age. In those cases, congenital or acquired, severe enough to require treatment, the clinical manifestations may be classified as follows: (1) Jaundice; (2) splenomegaly, usually accompanied by enlarged liver; (3) anemia; (4) decreased resistance of the red blood cells; (5) urobilinuria; (6) an increased urobilin content of the stool.

A synopsis of the history and clinical findings in a boy, aged nine years, recently examined and operated on[1] at the Mayo Clinic, will serve to illustrate the typical features occurring in hemolytic jaundice: (1) Jaundice since birth with acholuric crises. (2) Large spleen (reaching below the umbilicus). (3) Large liver (4.5 inches below the costal margin). (4) Increased fragility of the erythrocytes, complete hemolysis taking place at 0.4 per cent. (5) Complete blood count: hemoglobin 24 per cent., erythrocytes 1,340,000, color index, 0.8 per cent., leukocytes 15,200, number of cells counted 300, with a differential count of: polynuclear neutrophils 59 per cent., normoblasts 57, small lymphocytes 29 per cent., large lymphocytes 40 per cent., eosinophils, 2.3 per cent., basophils 2.7 per cent., neutrophil myelocytes 3 per cent. There were marked anisocytosis, slight poikilocytosis, marked degeneration of the red cells, marked polychromatophilia; coagulation time ten minutes. (6) Recent nosebleed. (7) No urobilin in urine, probably on account of the fact that the patient had had no recent acholuric crises. (8) Wassermann test negative.

Jaundice.—The jaundice is acholuric in character. In the familial type, it exists from birth; in the acquired type, the history is of shorter duration. The jaundice is essentially chronic in character, marked at intervals by a definite deepening of the jaundice, the so-called acholuric crises, accompanied by headache, fever, malaise, weakness and sometimes severe abdominal pain simulating gall-stone colic. It is indeed probable that the attacks of pain are in some instances due to gall-stones or infection in the gall-bladder and ducts. During these crises the spleen becomes enlarged and tender. There is evidence of marked hemolysis as expressed by the presence of urobilin in the urine, bile pigment in the blood in some cases and deepening of the jaundice. The jaundice is pigmentary in character and does not produce the toxic symptoms usually connected with obstructive jaundice. There is no itching, no bradycardia, no petechia; the stool is of normal color and there is no bile in the urine. If the common duct is obstructed during this crisis by the passage of gall-stones, the clinical picture will be complicated by evidence of obstructive jaundice. Crises may occur frequently or be absent for several years. In the intervals, urobilinuria may be absent and no evidence of hemolysis exist except as shown by the blood picture. To illustrate the irregularity of the occurrence of attacks we may say that the

[1] Balfour, D. C.: Surgery of the Spleen, Internat. Abstr. Surg., 1918, xxvi, 1–15.

above-mentioned case in the boy, aged nine, gave a history of slight jaundice since birth. Up to three years of age he had spells of fever accompanied by weakness, lassitude and loss of appetite, but was then free from the spells until one year ago, since which time the attacks have occurred every two or three months, accompanied by deepening of the jaundice.

Splenomegaly.—During the so-called acholuric crises the spleen usually becomes markedly enlarged and somewhat tender. This temporary splenomegaly may be evident to the patient as indicated by a sense of fulness or a definite protrusion of the abdominal wall. Following the crises the splenic tumor subsides, but probably fails to reach its former size. In 47 cases of splenomegaly, congenital and acquired, collected by Elliott and Kanavel,[1] the weight of the spleen was noted in 28. The average weight was over 1000 grams; 1 spleen was reported as weighing 4500 grams; in only 7 was the weight under 950 grams. It is very difficult to determine the time of the onset of splenomegaly; it is probable, however, that it occurs early in the disease.

Blood.—The changes in the blood will, of course, depend on the degree of activity of the disease at the time of the examination and and the ability of the hematopoietic system to produce new blood. Regeneration of the blood is indicated in a majority of cases by the presence of nucleated red cells. There is no blood picture which is characteristic of the disease. The number of red cells is found to vary widely in a given group of cases. In some instances they may number as low as 1,000,000; or, on the other hand, may be present in nearly normal numbers. Usually, however, there is a decrease, the average being 3,000,000 to 4,000,000 with the color index of 1 or in the neighborhood of 1. In severe cases a higher color index may be present, suggesting pernicious anemia. It has been noted that the erythrocytes are usually decreased in size but show very little, if any, change in shape. The presence of normoblasts has been reported on several occasions. Richards and Johnson[2] reported the presence of Jolly bodies in some instances and also large, coarse, irregular-shaped basophile granules in the red cells. If the blood be treated by one of the methods of postvital staining, a peculiar network of granules or threads, termed "substantia granuloreticulo-filamentosa" may be observed. These structures are thought by some observers to indicate active regeneration; their exact significance is yet undetermined. The leukocytes usually exist in normal numbers, and the differential count does not show any characteristic change. During the crisis, a slight temporary leukocytosis is usually present.

Increased Fragility of the Erythrocytes.—It has been demonstrated that red blood cells in obstructive jaundice possess an increased resistance to hemolysis by hypotonic salt solution. Applying this test

[1] Surg., Gynec. and Obst., 1915, xxi, 21–37.
[2] Jour. Am. Med. Assn., 1913, lxi, 1586–1590.

(P. Ribierre's method[1]) in hemolytic jaundice, we find almost constantly a decreased resistance to hemolysis and increased fragility of the erythrocytes. In a few reported cases the resistance of the red cells was normal. Decreased resistance of the red cells to hypotonic salt solution has been found to exist in other conditions, but evidently it is of very rare occurrence. The test has been cited as an aid in differentiating hemolytic jaundice from pernicious anemia and splenic anemia.

Urobilinuria.—In practically every case, and especially during a crisis, urobilinogen is present in the urine. In contrast to obstructive jaundice, bile is not found in the urine except in cases complicated by the passage of gall-stones. In a few cases bile pigment is reported as present in the blood. The amount of urobilin in the urine may be used as an index of the extent of hemolysis. It is generally conceded that the hemoglobin is split up in the liver-spleen circulation into an iron-containing element (hematin) and pigment-containing element which is excreted by the liver as bilirubin. In the intestine bilirubin is converted into urobilin, absorbed and excreted as such by the kidneys.

Stool.—Urobilin is always found increased in quantity in the stool. The output may rise from the daily normal, 0.15 gm. to 4 gm.

Diagnosis.—A diagnosis can usually be made without great difficulty. In some instances it may be impossible to state whether a given case is congenital or acquired. This is due to the fact that the light form of congenital hemolytic jaundice may have existed for years unrecognized by the patient, so that we are unable to obtain a definite history. A long-continued history of remittent or intermittent jaundice, together with marked splenomegaly, anemia and increased fragility of the red cells, constitute a definite clinical picture. Cholangeitis with cirrhosis of the liver, which is discussed under splenic anemia, will sometimes present difficulty. In this condition the erythrocytes possess an increased resistance to hemolysis, the spleen is not so large, and bile is present in the urine. Many cases have

[1] We have taken from Sahli's Diagnostic Methods (edited by Potter, 1911, Saunders, Philadelphia, 2d ed.) the following copy of Ribierre's method of testing the fragility of the red cells: "Ribierre uses a 0.5 per cent. solution, and places in a very small test-tube 50 drops; in a second, 48; in a third, 46 drops, etc., and then adds distilled water sufficient to make 50 drops in each tube. A definite amount of blood (20 c.mm.) is put into each tube from the capillary measuring pipette. Normally, the hemolysis begins in a tube containing 44 drops of salt solution and 6 drops of distilled water, and is complete in the fifth or sixth following tube. The results are described as 'slight,' 'distinct,' 'very distinct,' and 'complete,' and one states in which of the dilutions these grades of hemolysis are found. French writers previously represented the results of these determinations in the form of a curve, the abscissa of which represented the number of drops of salt solution used, and the ordinates represented the four grades of hemolysis.

"One can then easily calculate at what percentage concentration of the hemolysis begins. If, for instance, the tube containing 44 drops express the extreme concentration, the percentage will be 44/50. 0.5 per cent. = 0.44 per cent.

"With a sensitive blood, Ribierre begins with stronger saline solutions, *e. g.*, 0.7 per cent., and puts in the first tube 70 drops; in the second, 68; then 66, 64, etc., and adds distilled water up to 70 drops in each case. If hemolysis begin in the tube containing 64 drops, the saline concentration is 64/70. 0.7 per cent. = 0.64 per cent."

probably been overlooked in the past and placed in the splenic anemia group chiefly because the physician failed to obtain a history of jaundice.

Prognosis.—In the mild form of the disease, that is, when symptoms are absent and only a slight icterus exists, the prognosis is very favorable even without medical intervention. Such patients suffer no inconvenience and are able to perform their daily duties, living to old age. In the more severe forms the illness is progressive and gall-bladder complications are likely to occur. The patient gradually becomes weak and emaciated and ultimately dies of the disease.

Treatment.—In the mild type of the disease, treatment may not be required. Cases of familial jaundice have been known to exist when the patient lived to an old age. In the more severe forms of the familial type and in the acquired type medication is only of temporary benefit. On the other hand, splenectomy has been followed by such gratifying results that operation should be advised in every case. Even when the disease is of the mild type, but progressive, surgery should be considered. So far as can be learned from statistics, it would seem certain that splenectomy interrupts the progressive nature of the disease and is followed by excellent results. Of the 47 cases collected by Elliott and Kanavel, only 2 patients died; 1 shortly after operation and the other six weeks after the operation from sepsis. Such a small mortality is very satisfactory, especially when taking into consideration the serious condition which existed in many of these patients at the time of operation.

In regard to the immediate effects of splenectomy, it is striking how quickly the jaundice begins to subside. In a few days after operation a distinct clearing of the skin takes place and the jaundice entirely disappears in two or three weeks. The acholuric crises cease. Among the 47 cases collected are those of Spencer Wells reported by Dawson, the patients operated on twenty-seven years ago, Roth's case six years ago, Bland-Sutton's case ten years ago, and Banti's case eleven years ago. Forty-six of the patients are reported as cured.

The effect of splenectomy on the blood picture is very striking. Within a few weeks the red cells approximately reach normal and the increase is always accompanied by a rise in the hemoglobin. The leukocytes also reach normal in a very short time except when complications are present. With regard to the fragility of the erythrocytes, apparently there is little or no change in many of the patients. In all the splenectomized patients the fragility of the red cells was increased previous to operation. One patient was reported as returning to normal in five weeks after operation, and several at the end of three months. In Spencer Wells's patient, however, increased fragility still existed twenty-seven years after operation and in Roth's three and one-half years after operation. Sufficient time has not elapsed to show the effect of the gall-bladder complications. It is reasonable to assume, however, that the tendency to such complications would at least be decreased.

Pernicious Anemia.—Pernicious anemia is a recent acquisition to the field of surgery. It is our purpose, therefore, not to deal in detail with its clinical manifestations, but rather to limit ourselves chiefly to treatment with special reference to the influence of splenectomy on the progress of the disease. In view of the fact that medical treatment has been followed by such unsatisfactory ultimate results, it is not surprising that splenectomy has been undertaken in a considerable number of cases.

Pernicious anemia may be defined as a systemic disease of unknown origin, having for its chief clinical characteristics the following cardinal manifestations: (1) Anemia of a progressive course usually with recurrent exacerbations; (2) a blood picture in which there is revealed a marked decrease in erythrocytes with a relatively high hemoglobin content; (3) the presence of anisocytosis, poikilocytosis, polychromatophilia, megalocytes, normoblasts and megaloblasts. The skin is of a lemon-yellow tinge and parasthesias are common. The patient is apt to be very weak and debilitated. Cardiac and gastro-intestinal symptoms may be prominent. In a majority of cases there is no marked enlargement of the spleen and liver. Since our attention has been centered upon the spleen as an etiological factor in various diseases of the blood, splenic enlargement is being demonstrated in many cases of pernicious anemia. In those cases submitted to operation the spleen was usually found to be enlarged, but in many instances not sufficiently enlarged to allow of its palpation at the time of examination.

Etiology.—In pernicious anemia, the essential pathological process is not in the spleen, but in the bone marrow. Moffit[1] believes with Warthin that the infective agent or toxin of pernicious anemia may act differently at different times, or that there may be several hemolytic poisons and that there may be splenic, lymphatic, hemolymphatic or marrow hemolysis. Moffit continues and says: "That the shifting clinical picture, the varying reaction at different times to remedial measures like arsenic, thorium X, salvarsan, splenectomy, the marked hemolysis in some cases (urobilinuria, icterus) and its absence in others, the inconstancy of marrow reaction—all speak for a widespread influence of the poisons in the economy with maximum effects apparent now in this organ and now in the other." Since it has been proved that anemia of the pernicious type is produced by chemical substances and the poisons elaborated by certain parasites, suggestions have been made that certain cases of pernicious anemia may be due to toxins which are formed in or reach the blood stream by way of the alimentary tract. The theory of chemical poisoning is supported by King's work previously mentioned in the chapter on hemolytic jaundice, with reference to the occurrence of unsaturated fatty acids in the blood. The toxins are supposed to be influenced in some way and possibly intensified by the spleen. The fact that the removal

[1] Am. Jour. Med. Sc., 1914, cxlviii, 817–827.

of the spleen in the late stages of the disease has been followed by a cessation of hyperhemolysis, tends to prove that the spleen is at least a link in the chain necessary for the production of the disease. Some observers compare the spleen with other glands of internal secretion and speak of its activity in the hemolytic anemias as hypersplenism. The exact status of this condition has not as yet been definitely determined, nor are we certain of the location or manner in which hemolysis takes place. It has been suggested that the corpuscles are sensitized through the influence of the spleen and are later destroyed in the liver, lymph glands and bone marrow. As Roblee[1] concludes, however, it is probable that no one pathological process is responsible for all cases.

Pathology.—Until recently our knowledge of the pathology of the spleen has been acquired from a study of the organ at postmortem examination. Since splenectomy has been practised in pernicious anemia, it has been found that the spleen is usually enlarged during the early stage of the disease. In the late stages or at death the spleen is usually described as being atrophic and showing marked fibrosis and pigmentation.

Wilson,[2] in an analysis of 7 cases of splenectomy for primary pernicious anemia, found that in 6 cases the spleen was larger than normal. In only 1 instance was the spleen smaller than normal, and weighed 195 grams. The average weight in the 7 cases was 463 grams. The organ is usually firm, but not tough, and cuts freely. With one exception Wilson found on microscopic examination a marked increase in lymphoid tissue. There was only slight fibrosis and arteriosclerosis was absent. Hyperemia of the pulp and thickening of the follicular arteries have been noted by Eppinger and others. In Wilson's series, however, these features were absent and there was slight pigmentation in only 1 case. In the spleen which showed only slight increase in lymphoid tissue, there was a marked degree of diffuse hypertrophic fibrosis and slight arteriosclerosis.

Diagnosis.—Pernicious anemia may usually be easily recognized. A severe progressive anemia, for which no cause can be assigned, weakness, languor, debility, a blanched, waxy appearance of the skin, which has a faint lemon tint, a preservation of the subcutaneous tissues and the body weight to a remarkable degree, tendency to gastric intestinal disorders, and the frequent occurrence of signs and symptoms of involvement of the central nervous system, constitute a clinical picture which should at least make us suspicious of the presence of pernicious anemia. The diagnosis is further strengthened by a history of one or more remissions occurring during the course of the disease. In order to confirm the diagnosis, however, a microscopic examination of the blood is essential. In the early stage and during a remission, the blood may not show a typical picture. Under these conditions, mistakes in diagnosis are most likely to be made.

[1] Jour. Am. Med. Assn., 1915, lxiv, 796–800.
[2] Ann. Surg., 1915, lxii, 158–165.

Severe anemia of the secondary type accompanying certain conditions and diseases is liable at first sight to occasionally be confused with pernicious anemia. If complete clinical and laboratory methods are employed, mistakes in diagnosis will seldom be made. Defining pernicious anemia as a disease of unknown origin, it is our duty in all cases of severe anemia to make an exhaustive search for a possible etiological factor. Cancer of the alimentary tract, and especially of the stomach, is usually credited as most commonly confused with pernicious anemia. If a thorough microscopic examination of the blood is made and the roentgen rays employed to prove or disprove the presence of gastro-intestinal lesions, a correct diagnosis will usually follow.

Intestinal parasites, such as dibothriocephalus latus, uncinariasis and Entamebæ histolytica, may be eliminated by careful examination of the stool. In syphilis we must depend on the Wassermann test, together with careful inquiries for evidence of the disease.

In the anemias of infancy, with a blood picture resembling that of pernicious anemia, etiological factors such as rickets, inherited syphilis, nutritional disturbances, should be sought.

Careful search must be made for points of hemorrhage. Occasionally severe grades of secondary anemia may result from repeated hemorrhages, which are disregarded by the patient, so that careful inquiry for such causes is necessary.

On examining the duodenal contents by special methods, Schneider[1] found urobilin and urobilinogen in large quantities in cases of pernicious anemia, whereas in secondary anemias urobilinogen was absent, and there were only small amounts of urobilin.

Treatment.—Before treatment is begun we should employ every known means to discover the possible existence of some factor which may produce a clinical picture resembling that of pernicious anemia. In this respect it is most important to have the stools carefully examined for parasites. There are cases of severe anemia difficult to differentiate from pernicious anemia which are associated with Entamebæ histolytica. Entamebæ may be present and bear no causal relationship to the anemia. The Wassermann test should be done in every case. It is well known, especially since the Wassermann test has been introduced, that occasional cases of anemia indistinguishable from pernicious anemia are the result of syphilitic infection.

The complete cure of pernicious anemia by medical means has never been attained. Our chief aim has been to abort exacerbations and prolong remissions. Absolute rest in the treatment is essential. Rest, together with an abundance of fresh air, a liberal and nourishing diet, will often produce a decided improvement. With regard to drugs, the majority of physicians rely on the various arsenic compounds and large doses of iron; Fowler's solution is usually employed and should be given in large doses. Salvarsan has been given with no

[1] Arch. Int. Med., 1916, xvii, 32–41.

very positive results. Idiosyncrasies to the drug and poison from its prolonged use should be recognized. In our own experience the intramuscular injection of iron arsenite has been followed by very satisfactory improvement in some of the severest cases. Other methods of treatment such as oxygen inhalation, ingestion of bone marrow, thorium X, have no advantage over the arsenic therapy.

Transfusion of Blood.—Transfusion of blood has recently received a great deal of attention and is advocated for anemias of both the primary and secondary type. Its employment seems to be attended by satisfactory temporary results. With repeated transfusion the blood picture will often improve in patients who do not respond to the arsenic compounds. The variability in results depends for the most part on the stage of the disease and the time at which the treatment is instituted. When the patient is at the height of a recurrence, efforts to obtain relief may be absolutely fruitless, and on the other hand, brilliant temporary results are usually obtained by any method at a time when the patient is entering upon a state of remission. Ottenberg[1] and Libman[2] state that of 25 cases of pernicious anemia treated by transfusion, 14 showed, for a time, progressive improvement, but all continued to present evidence of the disease. In 11 cases transfusion was of no avail. They conclude that blood transsion induces a remission in about one-half of the patients and that, if the first transfusion fails, the blood from another donor should be used. Many observers hold that transfusion should be allowed a thorough trial before splenectomy is resorted to and that in splenectomized patients blood should be transfused before and after operation. If untoward symptoms occur after the first transfusion, a second transfusion from the same donor should not be attempted.

The technic of blood transfusion by the citrate method (after Lewisohn) is as follows:

The arm of the donor is prepared in the usual manner, a tourniquet is lightly applied above the elbow and the vein (medium cephalic or medium basilic) is either punctured with a large-sized needle or exposed by a small incision and a cannula introduced. The blood is received in a sterile graduated glass jar containing 25 cubic centimeters of a 2 per cent. sterile solution of sodium citrate at the bottom. While the blood is running it is well mixed with the citrate solution by means of a glass rod. After the blood has reached the 250 c.c. mark another 25 c.c. of the citrate solution is added and the blood permitted to flow until there are 500 c.c. of the mixture. If more blood is desired a sufficient amount of the citrate solution is added to maintain the ratio at 0.2 per cent.

The blood may be carried to a recipient's room or the recipient brought into the operating room. The recipient's vein is then exposed by a small incision; the cannula introduced and attached to a salvarsan flask or irrigating flask. The rubber tubing and the bottom of

[1] Jour. Am. Med. Assn., 1915, lxiv, 613. [2] Ibid., 2163–2164.

the flask are filled with saline solution to prevent air from getting into the circulation. The citrated blood is then transferred into the flask and permitted to flow into the vein of the recipient. There is no occasion for hurry for the blood will not clot, but on the other hand it is advisable to have the blood run in slowly in order to guard against suddenly overloading the right heart and in order to watch for any untoward effect on the patient. The marked slowing of the pulse, syncopal attacks, dyspnea, cyanosis, sensation of cardiac oppression, or "peculiar" or "funny" pains throughout the body should be interpreted as danger signals, and if these persist after temporarily stopping the flow it is advisable to conclude the operation at once.

Robertson[1] studied 4 cases of primary pernicious anemia treated by blood transfusion with a view of determining the effect of the treatment in the excessive output of urobilin. Three of the 4 patients transfused gave evidence of a resulting bone-marrow stimulation and at the same time showed a temporary increase of urobilin excretions. In one instance there was no change in the output of urobilin.

Blood.—The varying degrees of reaction and the ultimate behavior of the blood may depend upon the condition of other organs at the time of operation and especially on the condition of the liver, lymphatic glands and bone marrow. In no instance has the blood definitely departed from the pernicious type, but there is usually great improvement in the degree of anisocytosis and poikilocytosis. Megaloblasts decrease and the color index fails. Megalocytes disappear more slowly and even when the patient feels quite well, the blood will remain megalocytic in type. The immediate occurrence after operation of immense numbers of normoblasts, reticulated red cells, and erythrocytes with Howell's Jolly bodies is characteristic of practically all cases and indicates a marked marrow reaction. Normoblasts usually persist three to four weeks and then gradually disappear. Howell's Jolly bodies may be found several months after operation. The leukocytes may or may not increase after operation.

Hemolysis.—In the larger number of operations, hyperhemolysis was present, as indicated by urobilin in the urine, an excess of urobilinogen in the stools and an icteroid tinge of the skin. With few exceptions, these features were more or less definitely absent very shortly after splenectomy. In a study of 6 cases of primary pernicious anemia in which there was an increased output of urobilin previous to splenectomy, Robertson found that there was a decided decrease in the output of urobilin in all. In 2 of the cases the urobilin later returned to a high point and in one the output remained about normal. These 3 patients received less benefit from the operation than 2 patients who had a normal output twenty-seven months after splenectomy. In those instances where gastric disturbances were pronounced, several observers have noticed that after operation, the appetite immediately improves and gastric symptoms subside.

[1] Arch. Int. Med., 1915, xvi, 429–436.

Splenectomy.—Any form of treatment for pernicious anemia may prove, or at least may appear to be, beneficial. Even without treatment these patients have their ups and downs, and it is not an infrequent clinical experience to have a patient present himself with symptoms which might be construed as being those of an early pernicious anemia, and then with or without treatment recover and remain well. In eliciting the history the physician finds that the symptoms are often indefinite in the earlier stages, before the blood changes become characteristic.

Splenectomy in pernicious anemia does not appear to be based on sound reasoning, and there seems to be no foundation for the belief that the procedure will cure pernicious anemia. Eppinger first suggested splenectomy as a cure for pernicious anemia, and the early reports with the abundant testimony as to temporary relief were quite sufficient to give the operation a fair trial in this hopeless disease. Considering the confusion which so often attends the early diagnosis, it seems probable that obscure cases of hemolytic icterus and splenic anemia have been accidentally included in the pernicious anemia group. Removal of the spleen in such cases has given the impression that splenectomy cures pernicious anemia. At the same time in the investigation of our cases of splenectomy for pernicious anemia we see great, though temporary, improvement. There is a gain in weight and an improvement in the blood from an average hemoglobin of 38 to 72 per cent., and the reds from two to four millions. Splenectomy seems at least to have instituted a marked palliation.

In our experience in the cases in which the results were most favorable the symptoms were less characteristic of pernicious anemia. In young and middle-aged persons in whom the disease is most rapid, especially if hemolysis is shown to be marked, splenectomy is worthy of trial. Taken as a whole, it may be said that whenever pernicious anemia has developed to the stage in which the blood is characteristic it is incurable, and splenectomy is a means of palliation and not of cure. Since there is an operative mortality, good reasons must exist for substituting operation for repeated blood transfusions. We have splenectomized 50 patients with pernicious anemia, with three deaths (6 per cent.).

Although the general condition of the patient as well as the blood rapidly improves after splenectomy, yet it would seem probable that the essential hemolytic agent has not been eliminated. As proof of this, we have the following facts:

1. Persistence of a pernicious type of blood picture, even though the patient attains a prolonged clinical remission.
2. Failure of a few patients to respond to the operation.
3. The occurrence of relapses in a few instances following an initial improvement after splenectomy.
4. Persistence and progressive nature of cord lesions. The patient or his family should receive a full and frank explanation of the prognosis of the disease and the present status of surgical treatment before splenectomy is decided on.

If all patients with primary pernicious anemia were carefully considered and proper pre-operative treatment instituted, there is no apparent reason why the mortality should exceed that of splenectomy in other conditions. Of 207 splenectomies at the Mayo Clinic, up to January 1, 1919, for the various diseases associated with splenomegaly, there was a death-rate of 9.1 per cent. Fifty-one of the 207 splenectomies were performed for primary pernicious anemia with three operative deaths. Robles collected 40 cases and found that 9 patients had died either at operation or shortly after.

Splenomedullary Leukemia.—The results of the surgical treatment of splenomedullary leukemia in the past have been very discouraging. The earlier operative experience was associated with such a high initial mortality that the operation was practically abandoned.

Warren, who in 1911 reported one case of splenectomy for this condition, followed by recovery, and referred to the 42 cases collected by Hagen, with 4 recoveries, attributed the serious operative risk to secondary hemorrhage from the wound. It must be remembered that at the time these unfavorable results were reported splenectomy was performed during the active period of the disease, and when the number of white cells was large, showing a high ratio to the red cells. There have been since that time isolated reports of splenectomy for splenomedullary leukemia, in some of which the diagnosis was rather seriously doubted (Richardson).

The surgical profession has hesitated, therefore, to adopt operative measures in this disease, but since it has been demonstrated that radium, *x*-rays and benzol exert a specific, although temporary, effect on the symptoms of myelogenous leukemia (Billings and others), splenectomy has again come up for consideration. Radium appears to exert the most powerful influence on the spleen and on the blood picture, and there have been several cases reported of remissions that have been produced by radium in conditions entirely resistant to *x*-rays and benzol (Ordway,[1] Giffin[2]).

The therapeutic value of these agents being sufficient to bring the blood picture to normal, greatly to improve the patient's general condition and gradually to reduce the size of the spleen (in some instances until it is non-palpable), suggested the possibility that removal of the spleen at this stage might have some influence on the course of the disease, particularly if these therapeutic agents were used as adjuncts. It has already been demonstrated that under such circumstances splenectomy may be done with a very low operative mortality. In the Mayo Clinic between October 2, 1916, and September 1, 1917, 17 patients were operated on who had splenomedullary leukemia in which the blood picture had been first brought to normal by the use of radium, *x*-rays or benzol or a combination of these agents. There have been no

[1] Remissions in leukemia produced by radium in cases completely resistant to *x*-ray and benzol treatment, Tr. Asso. Am. Phys., 1916, xxxi, 177–207.

[2] Observations on the treatment of myelocytic leukemia by radium, Boston Med. and Surg. Jour., 1917, clxxvii, 686–691.

operative deaths in this series, but we have as yet no knowledge as to the ultimate results of the operation.

Splenomegaly and Anemia Associated with Syphilis.—Under splenic anemia, we have directed attention to a group of cases in which there are marked splenomegaly and anemia of the secondary type associated with syphilis. Enlargement of the spleen is not uncommon in early syphilis, but it tends to disappear. In certain cases, however, the splenomegaly persists and ultimately these patients may present a clinical picture which is identical with that of splenic anemia. Gummata of the liver are often present, or there may be a definite cirrhosis, with or without ascites, thus simulating the Banti type of splenic anemia. In all patients, therefore, having an enlarged spleen, careful inquiry for syphilitic infection and repeated Wassermann tests are imperative before a diagnosis is made. It is probable that marked splenomegaly may be present in patients with syphilis, in which syphilis bears no etiological relationship to the splenomegaly. To obtain a satisfactory classification, however, it would seem quite proper to separate from other forms of splenomegaly those cases in which there is evidence of syphilis, or in which repeated positive Wassermann tests are obtained. Three cases of this type have been carefully observed over varying periods of time at the Mayo Clinic and splenectomy was ultimately performed. Giffin[1] reports these cases in detail and collects 5 unoperated and 3 splenectomized cases from the literature. The unoperated cases simulated the Banti type of splenic anemia. Three of them came to autopsy. Of the 3 patients not operated on, 2 received antisyphilitic treatment with no benefit. Following operation improvement was prompt. The third died two years after operation, as a result of severe hematemesis. Of the 5 patients examined and operated on at the Mayo Clinic, only 1 gave a history of primary infection. The Wassermann test, however, was strongly positive in the other 4.

In studying these cases, we were impressed with the similarity of the clinical picture to that of splenic anemia and recognize the fact that without the aid of the Wassermann test, mistakes in diagnosis would often be made. The 3 patients received antisyphilitic treatment with only slight benefit. The condition of the blood did not improve and the splenomegaly persisted. After splenectomy, improvement was prompt and progressive in each. Reports were received from our patients one year, eight months and two months, respectively, after splenectomy. In each instance, the patients were enjoying excellent health and the anemia, which previous to operation had been marked, had entirely disappeared.

Cirrhosis of the Liver.—While an etiological classification of cirrhosis of the liver is highly desirable, our present knowledge does not lead to a satisfactory grouping. The chief clinical characteristics are clarified by the pathological conception of biliary and portal

[1] The Treatment by Splenectomy of Splenomegaly with Anemia Associated with Syphilis, Am. Jour. Med. Sc., 1916, clii, 5–16.

types. Biliary cirrhosis resulting from infectious cholangitis of ascending origin and probably occasionally from a hematogenous infection causes chronic jaundice which is an early and a most pronounced clinical sign. The symptoms and signs of portal obstruction come late or not at all. On the other hand, portal cirrhosis probably has its origin in the portal system as a result of infectious material or toxic substances obtained from the gastro-intestinal tract. Ascites, other signs of portal obstruction, come early and jaundice is a late manifestation. There are many minor distinctions and mixed types undoubtedly occur. Varying grades of hemolytic activity may be found in both types but are especially noted in biliary cirrhosis. The terms "hypertrophic," "atrophic," "alcoholic," etc., often lead to confusion when applied to cirrhosis of the liver.

Eppinger has reported splenectomy in 4 cases of the splenomegalic type of hypertrophic cirrhosis of the liver associated with chronic jaundice and evidences of increased hemolytic activity. Complete subjective recovery resulted in all the cases. The icterus in 3 cases vanished completely.

Splenectomy in portal cirrhosis was first performed in patients on whom a diagnosis of the Banti type of splenic anemia had been made. At operation more or less advanced cirrhosis of the liver, out of proportion to the changes in the spleen, was found. The procedure is not as yet well founded, as an increased hemolytic activity has not been demonstrated in these cases. That definite improvement has followed splenectomy in advanced splenic anemia associated with cirrhosis of the liver is not an indication that similar results will be obtained in cases of primary portal cirrhosis. The course of the disease may, however, be affected by the decreased amount of blood that is carried through the liver after splenectomy; or some unknown factor may be active in these cases.

In the Mayo Clinic 14 patients with cirrhosis of the liver have been splenectomized. While the immediate results have been promising in some instances, and there are reasons to warrant the hope that in certain selected cases splenectomy may give a permanently good result, there is as yet no proof that removal of the spleen gives results which will be permanent.

Malarial Spleen.—In malarial fever the spleen is often greatly enlarged. Splenomegaly may persist in spite of medical treatment and may cause great discomfort and pain. It may possibly be a source of chronic malarial infection. A severe grade of anemia of the secondary type may develop in these patients, producing a clinical picture resembling that of splenic anemia. Enlarged and diseased spleens are liable to rupture even from slight trauma or they may become movable, so that the patient's life is further endangered by complications as a result of twisting of the pedicle.

The medical treatment recommended for malaria usually fails to reduce the size of the spleen. Datt[1] has used red iodide of mercury in

[1] Indian Med. Gaz., 1914, xlix, 372.

the treatment of enlarged malarial spleens. He claims to have reduced the size of the spleen and to have improved the general condition of the patient by this drug.

When the splenomegaly persists in spite of medical treatment and the enlarged organs continues to be a source of pain and danger to the life of the patient, splenectomy is advisable. Kopylow[1] reports the results of splenectomy in 13 patients who had large malarial spleens and collected 187 cases of splenectomy from the literature. The death-rate for the 200 cases was 25 per cent. Ten of the 13 patients were in excellent health at periods varying from six to twelve months after operation. Kopylow states that splenectomy is contra-indicated if the patient is weak, anemic and debilitated, and if there is much cachexia and hydremia.

On opening the abdomen, the enlarged spleen may be found firmly adhered to the diaphragm and surrounding organs. Under these conditions splenectomy may not be advisable because of the difficulty and increased risk of the operation.

Egyptian Splenomegaly.—A disease common in Egypt and evidently still limited to that country is described by Richards[2] as Egyptian splenomegaly. Data on the subject have also been contributed by Day and Ferguson[3] and Richards and Day.[4] The prominent features of the disease are: (1) Greatly enlarged spleen (2) anemia; (3) low leukocyte count; (4) attacks of fever; (5) cirrhosis of the liver, and, later, ascites. The condition is more common in early adult life. In Richards' series of 22 cases the age period ranged from seven to fifty years; 1 patient only being over thirty years. The average was twenty years. All but 3 of the patients were males. There seems to be a seasonal factor in the occurrence of the disease, 18 of the patients in this series having sought medical aid from March to August. Patients complained chiefly of abdominal enlargement and the pain and gastro-intestinal disturbance produced by the greatly enlarged spleen. Almost all experienced attacks of fever. The splenic enlargement evidently followed the onset of fever and rapidly increased in size with or without recurrence of fever. Cirrhosis of the liver occurs early and with rapid progress, leading to ascites and emaciation. In cases with marked ascites death usually takes place in about six months. Anemia is not extreme but is often aggravated by bilharzia and ankylostoma infection. Hematemesis occurs but rarely.

No cause has been assigned for this disease. Richards believes the splenomegaly is primary and the hepatic cirrhosis secondary. He draws attention to the similarity which exists between Egyptian splenomegaly and splenic anemia; but at the same time he emphasizes the fact that the clinical course of the two diseases is quite different.

[1] Arch. f. klin. Chir., 1901, ci, 708–734. Abstract, Jour. Am. Med. Assn., 1913, lxi, 312.
[2] British Jour. Surg., 1914, i, 419–433.
[3] Ann. Trop. Med. and Parasit., 1909–1910, iii, 379–394.
[4] Tr. Soc. Trop. Med. and Hyg., 1911–1912, v, 333–363.

In splenic anemia hepatic cirrhosis is the terminal state, whereas in Egyptian splenomegaly hepatic cirrhosis occurs early and is present in every case. In splenic anemia fever is practically absent; there is no seasonal variation and gastric hemorrhage is a common occurrence. In fact, the histories of the two diseases, when carefully considered, are quite different. In Egyptian splenomegaly tests for malarial parasites, Leishman-Donovan bodies and syphilis are negative. Quinin and salvarsan fail to produce any benefit or change the course of the disease. In the majority of instances the disease is progressive and death ultimately results from hepatic cirrhosis. A few patients recover spontaneously. Richards advocates splenectomy as the proper method of treatment. Of 22 patients operated on by Richards, 18 survived; 2 of 4 that died had reached the advanced stage of the disease with ascites. Richards now believes that patients who have reached the ascitic stage should not be submitted to operation. Owing to the great difficulty in tracing his patients after operation and because some of the operations had been performed recently, Richards gives a detailed account of postoperative results in 10 only of his series. Six of these were clinically cured: Several were doing hard physical work at periods varying from nine months to two and a half years after operation. One patient died five months after operation, cause unknown, and three could not be traced. He states that in properly chosen cases the mortality following splenectomy should be about 10 per cent. The largest spleen in the series was 2780 grams, the smallest 535 grams. The average weight was 1350 grams. The changes in the spleen are those of general hyperplasia. The liver shows a multilobular cirrhosis.

Kala-azar.—Splenectomy for kala-azar has been performed in a few instances. The disease is widespread in India, occurring in endemic, sporadic and epidemic form. Cases have also been reported from China, Egypt, Arabia and many countries bordering on the Mediterranean Sea. In the Mediterranean districts infants and young children are more susceptible to the disease than adults.

The parasite Leishmania donovani now accepted as the causal agent was first observed by Leishman in 1900 and his observations were confirmed by Donovan in 1903. It is found most numerously in the spleen, liver and bone marrow. It is also found in the blood and may be present in any organ of the body. Clinical and experimental evidence seem to indicate that the parasite is transmitted to the human body by the bed-bug. The onset of the disease is characterized by high fever, usually preceded by a rigor. The fever may be continued, remittent or intermittent in type and lasts several weeks. During this period the spleen rapidly increases in size and the patient becomes weak, anemic and emaciated. After a period varying from two to six weeks or longer, the acute symptoms subside, the temperature falls and the patient's general condition improves. This defervescence is in turn followed by a second period of fever and these periods of pyrexia and apyrexia alternate as the disease progresses. The spleen becomes

greatly enlarged and in the majority of instances extends below the umbilicus. The liver is also enlarged. The blood shows a secondary type of anemia which is rarely severe. A marked leukopenia is characteristic, the leukocyte count not infrequently dropping to 1000. Other symptoms are delirium, headache, edema of the extremities, swelling of the joints, petechia and gastric and intestinal indigestion. The duration of the disease is usually from six to nine months but may be prolonged from two to three years. Spontaneous cures have occurred; the mortality, however, is very high, reaching from 96 to 98 per cent.

The diagnosis is made certain only by the demonstration of the parasite. For this purpose, repeated examinations of the blood may be necessary. If the blood proves negative, splenic puncture or liver puncture may be resorted to and in most cases will be positive at all stages. This procedure, however, is not without danger.

During the early stage, the disease is apt to be confused with typhoid fever, malta fever and even splenic anemia and in some instances it is impossible to arrive at a diagnosis until the Leishman-Donovan bodies have been demonstrated.

Medical treatment, as will be seen from the high death-rate, is unsatisfactory. Various drugs have been used; atoxyl has been especially recommended. Bassett-Smith reports a case in detail, treated by intramuscular injection of atoxyl. After four and a half months of treatment, parasites could not be found in the liver or blood but were yet present in the spleen. The patient's general condition remained fairly satisfactory but anemia persisted and the spleen and liver remained enlarged. Kokoris states that splenectomy eliminates the chief focus of infection and should be done early. Kokoris,[1] de Souza[2] and Cochran[3] report a total of 10 cases in which splenectomy was done with variable but relatively satisfactory results.

The Technic of Splenectomy.[4]—The more frequent recognition of certain chronic disorders of the blood, particularly splenic anemia, hemolytic jaundice and pernicious anemia, and the therapeutic value of splenectomy in these and other diseases, have recently greatly extended the indications for splenectomy and suggested some observations on the technic of the operation. In our experience (especially in those cases in which technical difficulties are encountered) the operation has been facilitated by following a routine plan and by the precision with which the details of such a plan are carried out.

Through a left Bevan incision (Fig. 241), its length depending on the size of the spleen, the abdomen is explored. The suggestive frequency with which jaundice, attacks of epigastric pain simulating biliary colic, cirrhosis, and gall-stones, occur in many of the diseases for which splenectomy is advocated, necessitates an accurate record

[1] München. med. Wchnschr., 1915, lxii, 1008–1009.
[2] Arch. de méd. des enfants, 1915, vol. xviii.
[3] China Med. Jour., 1915, vol. xxix.
[4] We are indebted to Donald C. Balfour for the description of our technic.

of the condition of the liver, gall-bladder and bile passage. Such observations will ultimately possess specific value in the elucidation of the obscure but unquestioned intimate relationship between the spleen and the liver.

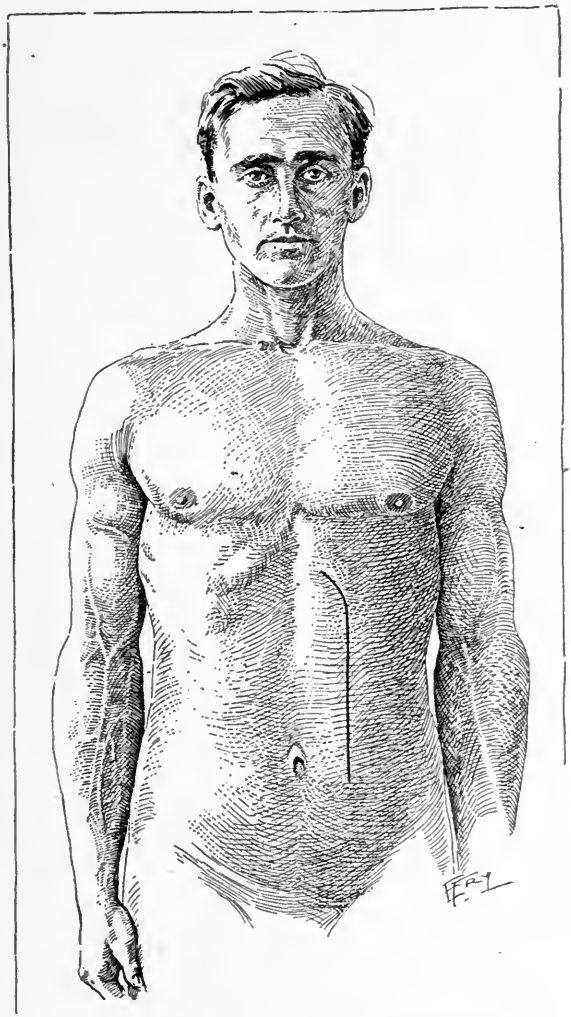


FIG. 241.—Bevan's incision as adapted for splenectomy.

The dislocation of the spleen from its position against the diaphragm and the left kidney (Fig. 242) should be the first step in the actual removal of the organ. The separation of the diaphragmatic adhesions can usually be safely accomplished by the fingers. If however, it is found that the adhesions have acquired bloodvessels of sufficient size to require ligation, it is then even preferable, in most cases, to

postpone such ligation (unless the vessels be reasonably accessible) until the spleen has been removed, the bleeding being temporarily controlled by a gauze pack described later. In an occasional case,

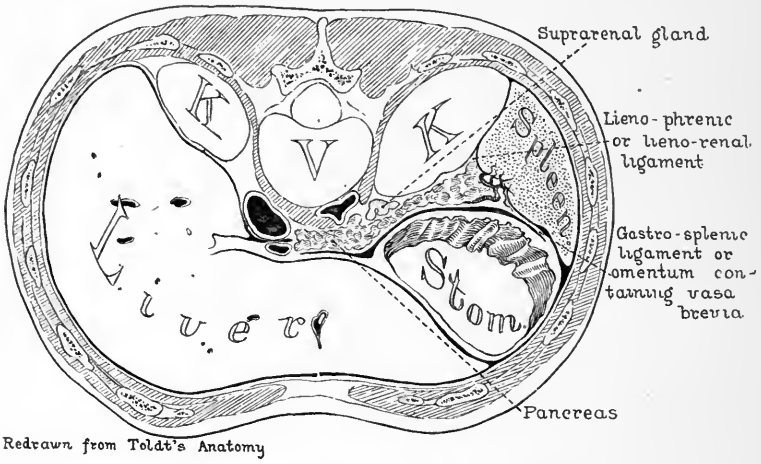


FIG. 224.—Diagrammatic representation of the important surgical relations of the spleen.

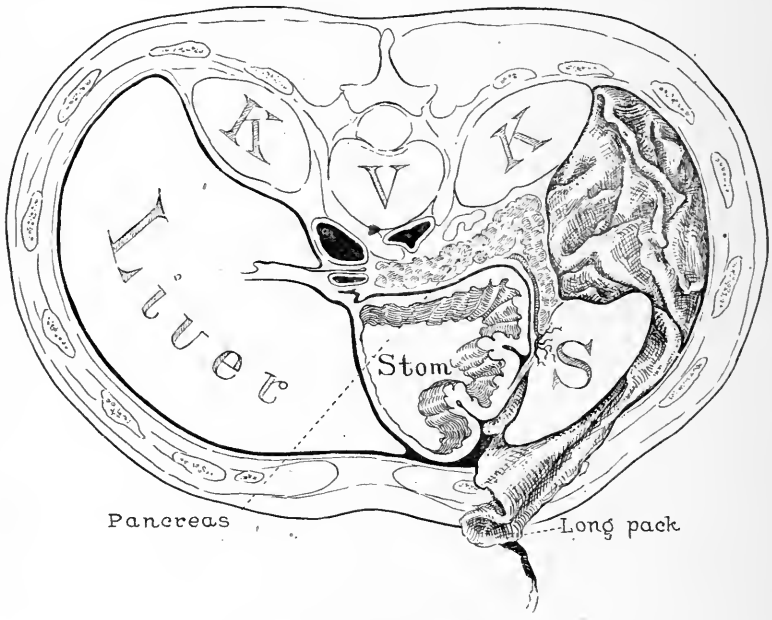


FIG. 243.—Position of gauze pack.

however, this stripping of adhesions cannot be done with safety, and and they must be divided between long curved forceps, care being taken to engage only the adhesions in the clamps. Hartmann and

others have advised that the operation be abandoned when these adhesions appear formidable. However, we have not recently found such conditions to be prohibitive to splenectomy, although in some cases absolute hemostasis has been secured with considerable effort.

Immediately the spleen has been dislocated, a long hot abdominal pack is efficiently arranged in the space formerly occupied by the spleen, until the entire area with which the organ has been in apposition, is under firm pressure by the gauze (Fig. 243). This accomplishes two purposes: (1) Most important, the oozing surfaces are compressed and, as the bleeding is usually venous, it is controlled without subsequent ligation, if the pack (a point emphasized by W. J. Mayo) is left undisturbed until the actual operation is completed. (2) An excellent support is provided for the safe manipulation and mobilization of the organ, the division of adhesions and ligation of the main pedicle.

The spleen having been elevated in this manner, its further connections are the main splenic pedicle with its peritoneal investment (the lineorenal ligament), the gastrosplenic omentum, and in splenomegaly of long standing, various adventitious adhesions. The most satisfactory isolation and treatment of the splenic pedicle is obtained by the preliminary division of the accessory adhesions, as well as the peritoneal attachments and reflections. The gastrosplenic omentum should first be divided, in sections as close as possible to the spleen, between ligatures. The only named vessels encountered are the vasa brevia, which arise from the splenic artery at variable points, pass to the greater curvature of the stomach, in this peritoneal fold, and finally anastomose with the left gastro-epiploic. In dealing with the upper edge of this gastrosplenic omentum, it must be remembered that here the fundus of the stomach is normally in very close apposition to the spleen. It is necessary, therefore, always to determine the exact relationship and protect the stomach from injury in its separation from the spleen. In an earlier experience I accidentally included in a clamp and excised a small area of the wall of the stomach, the resultant opening, however, being readily closed without postoperative complication. At the lower pole of the spleen there is an occasional fibrous attachment, derived from the phrenocolic ligament, which with the other adhesions, should be separately ligated.

The spleen may now be further mobilized by careful dissection of the peritoneal and fibrous coverings of the splenic pedicle. The localization of the tail of the pancreas is the important feature of this mobilization, and as the relationship of the organ is not constant, it is necessary to inspect it in all cases. In some instances the tail is short, lying against the renal surface of the spleen, on the posterior aspect of the pedicle, and it may be fitted so closely into the hilus of the spleen as to have acquired a concave edge. In other cases the tail is attenuated, it is in front of the splenic vessels, and in contact with the gastric surface, while often it does not extend into the operative field.

Fig. 244 shows the spleen "turned turtle" and represents a frequent relationship of the pancreas to the splenic pedicle. It is quite obvious that such a pedicle would not be ligated without including a portion of the pancreas. Fig. 242 shows that with the reflection of the lienophrenic ligament a better exposure is obtained of the tail of the pancreas; that it can be detached from its original position by dissection and allowed to drop back from the hilus of the spleen.

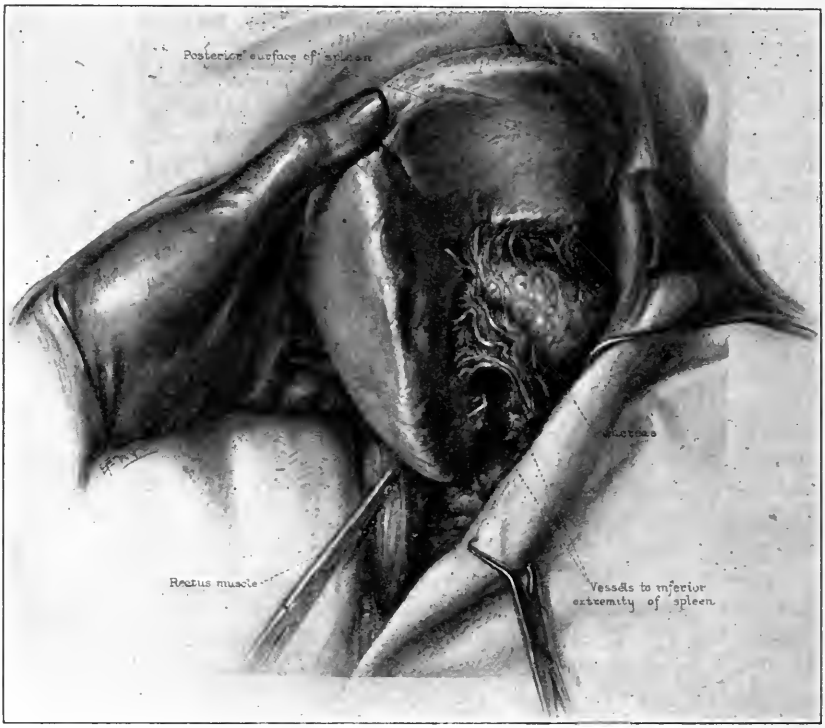


Fig. 244.—Posterior surface of spleen exposed, showing tails of pancreas, which lies in the splenic pedicle, posterior to vessels. The pancreas should be dissected from its position before clamps or ligatures are applied.

Therefore, after such dissection the splenic pedicle consists, from a surgical standpoint, of the splenic artery and its veins. The artery in some instances has divided before reaching the hilus of the spleen, although it often continues as a single trunk, well into the hilus while the veins are always in two or more branches. The latter do not bear a fixed position as regard the arterial trunks, lying in front in some instances, and behind in others. They are always distinctly larger than the artery itself, and their extreme friability must always be considered. The arrangement of the vessels of the pedicle is fan-shaped, as in Fig. 245 or 246, the breadth varying in different cases.

At this point it is possible to decide whether it is best to treat the pedicle *en masse* (Fig. 246) or to ligate it in sections (Fig. 245). The

latter method is to be preferred and the dissection of the pedicle is usually most advantageously carried out on its posterior aspect, with the spleen tracted toward the midline. The extent to which the

FIG. 245.—Ligation of splenic pedicle.

spleen can be lifted out of the abdomen by careful traction is surprising, if, following the division of the peritoneal and fibrous investments of the pedicle, certain of the lateral venous trunks are separately

isolated and divided between ligatures. It should again be emphasized that great caution must be exercised in the degree of traction to which the pedicle is subjected, and in the dissection of these veins. It is chiefly because of the normal tortuosity of the splenic artery that this elongation of the pedicle is possible, and thus facilitates its secure ligation. We have recognized the advisability of first securing, where it is possible, the arterial supply, so that the spleen may partially empty itself of its contained blood through the unclamped veins before these are ligated.

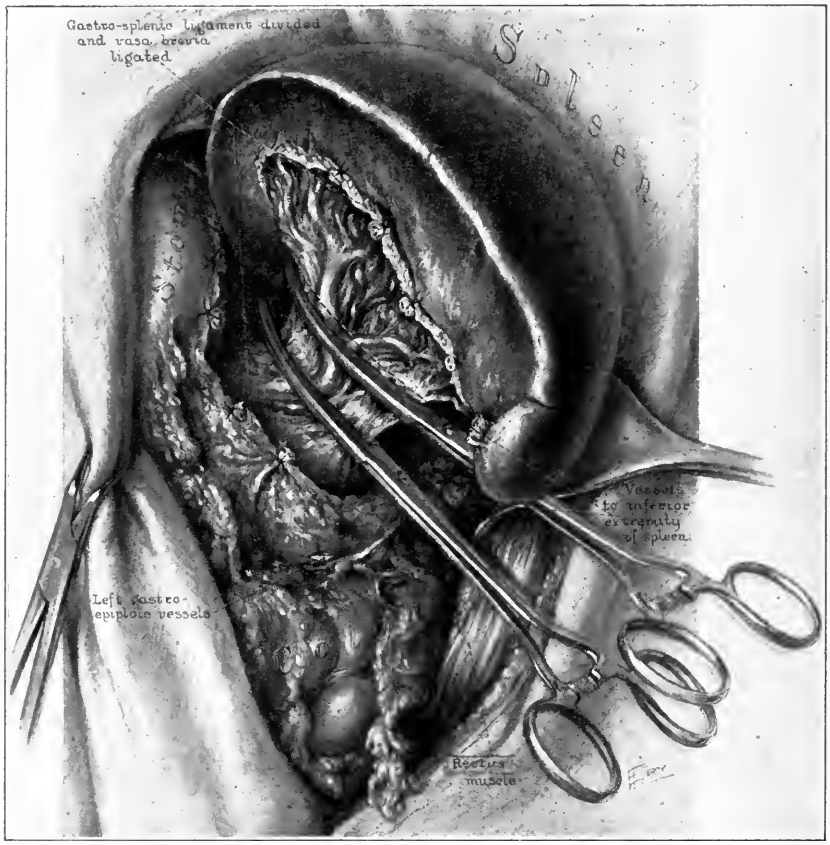


FIG. 246.—Peritoneal attachments separated, mobilizing spleen and permitting application of clamps. Pedicle to be divided at dotted line.

If, on account of the arrangement of the veins and arterial branches, ligation in sections is not advisable, ligation *en masse* by the two-clamp method, will prove a satisfactory and safe method. Two curved clamps are arranged on the pedicle with a third clamp on the splenic side to control "back bleeding," and the spleen is removed. A double strand of No. 2 plain catgut is tied with moderate tension in the

crushed line of the inner clamp, as a partial control, and a second strand is transfixed below the distal forcep as the actual control.

Having made certain, by either of these methods, that the pedicle is securely ligated, the large hemostatic pack is removed, the newly exposed surfaces inspected, any oozing points being separately secured by fine catgut on a needle, and absolute hemostasis assured.

The disease or condition for which splenectomy is done governs largely the technical difficulties and risk of the operation. I have found, for example, that in pernicious anemia, the removal of the spleen can be accomplished with comparative ease and safety. Although enlargement of the organ has been present in those cases in which we have advocated surgical treatment, adhesions are few and usually insignificant. The pedicle is, as a rule, small, and in a relatively small percentage is its treatment complicated by the relationship of the pancreas. Furthermore, the risk of the operation in this disease can be minimized by intelligent pre-operative treatment and observation, as well as by the careful selection of the cases. There must be a rational basis upon which splenectomy in pernicious anemia is advocated, as well as strict recognition of the limits of operative safety. Splenectomy is definitely contra-indicated during an acute crisis, or in a period when the patient shows a steady decrease in hemoglobin and red blood cells, or when mental torpor, cord changes and edema mark the terminal stages of the disease. Repeated transfusions from a suitable donor will frequently carry the patient through most critical exacerbations of the disease and the proper interpretation of the reaction following transfusion is essential. Further, it is important that a satisfactory donor be available after operation.

In splenic anemia, splenectomy is associated with a higher operative risk and greater technical difficulties than it is in any of the more common diseases of the spleen. In the cases I have seen, the spleen has been usually of large size, the vessels very friable and adhesions occasionally troublesome. Patients in the late stages of the disease are prone to develop fever, ascites, cirrhotic liver or severe anemia, which conditions contribute to the seriousness of the operation. The only instance in which I thought it inadvisable to attempt splenectomy, was in splenic anemia with great ascites, atrophic cirrhosis, and aneurysmal splenic vessels. The friability of the veins, due to a thrombophlebitis, which is a rather constant factor in such cases, was especially demonstrated in a baby twenty-two months old, upon whom I performed splenectomy for typical splenic anemia of the adult type.

The operation in hemolytic jaundice is of relatively little risk and there has been no particular difficulty in the removal of the spleen, although the organ is occasionally very large. It is, however, most important to avoid splenectomy during an exacerbation of the symptoms. Of the cases I have seen of this disease, the only operative death occurred in a patient in whom I failed to realize the import of a subacute and subsiding acholuric crisis.

In those cases of cirrhosis of the liver, associated with splenomegaly, in which splenectomy is to be considered, the spleen is often firmly adherent, and this fact, together with the poor general condition of the patient, makes the operation rather hazardous. Nevertheless, in the cases we have selected for operation, there has been no operative mortality; and in 2 cases of my own, most striking benefit followed the removal of the spleen.

In the rarer conditions, such as syphilitic spleen and idiopathic splenomegaly, the operation itself, is not of great risk. It has been interesting to note the result of splenectomy in 2 cases of splenomegaly with specific history and positive Wassermann. In both of these it had been previously possible to obtain a negative Wassermann by salvarsan, but it would become positive on discontinuing the treatment. Since splenectomy the Wassermann has remained negative.

From my own experience I have found that the features to be emphasized in the technic of splenectomy are (1) the abdominal exploration; (2) the dislocation of the spleen; (3) the use of a hot gauze pack; (4) the protection of stomach and pancreas from injury; (5) the preliminary ligation of adhesions; and (6) the treatment of the splenic pedicle.

DIAGNOSIS OF SURGICAL DISEASES OF THE STOMACH AND THE DUODENUM.

By FRANK SMITHIES, M.D., F.A.C.P.

General Considerations.—Disease of these portions of the alimentary tract may be *congenital* or *acquired*. Either type may give rise to *acute* or to *chronic* manifestations.

Acute ailments of the stomach or the duodenum are such as endanger life from starvation, intoxication, infection, loss of blood or rapid extension of disease to adjacent major viscera. In this group may be included acute stenoses of the orifices of the stomach, lacerations of the mucous membrane, wounds, rupture, sudden dilatation, tetany, and copious hemorrhage.

Chronic ailments of the stomach or duodenum, broadly considered, comprise that class in which patients seek relief from affections whose progression has resulted in stenoses and malformations of the viscera. Such affections are commonly associated with cachexia, malnutrition, anemia, abdominal distress, dyspepsia or imperfect function of related parts of the alimentary tract. Not rarely an *acute* manifestation may be superimposed upon a chronic disease, and may, in fact, wholly mask the primary ailment. Chronic surgical affections of the stomach and the duodenum are mainly those associated with the development of ulcer and cancer in these sections of the alimentary tract.

PART I.

CLINICAL HISTORY AND ITS INTERPRETATION.

As a guide to the proper management of patients, there is no clinical procedure which is of such importance as a properly developed anamnesis. While in many acute ailments of the stomach and duodenum, the history of the attack for which the patient seeks a physician, suffices for the determination of the immediately indicated surgical maneuver, yet to secure a comprehensive understanding of the case, it should be emphasized that careful inquiry should be made into the digestive upsets which have occurred during the months or years previous to the present complaint. This is to be urged especially in elucidating the nature of pathologic processes associated with chronic ulcer and with malignancy. Not infrequently it is quite difficult to have

the patient describe his indigestion during its earlier phases. The present symptoms may be so severe as entirely to occupy his mind. In such event, patience and intelligence are required to bring out the nature of the underlying affection. In all cases, and particularly in individuals in adult life, a determined effort should be made to detach patients from their immediate upsets and to have them give details respecting ailments which have occurred so long ago as almost to be forgotten. By this mode of inquiry, one is able to observe the nature of initial attacks of distress, the similarity or dissimilarity of attacks, the intermittence or constancy of the disease, the relative severity of the present and past exacerbations, the association with the disease of acute infections, trauma, dietetic errors, mental stress, the swallowing of foreign bodies, operative procedures and the influence of non-surgical treatment.

If such complaints are systematically tabulated, it is frequently surprising how readily similar chronic disease of the stomach or the duodenum classifies itself into definite symptom-groups and how definitely extragastric disease, associated with dyspepsia, can be segregated. In obtaining clinical histories, certain data regularly should be recorded.

Sex.—Up to within the past decade, groups of statistics were available which appeared to indicate that affections of the stomach and the duodenum were more common, or at least quite as common, in females as in males. The popularity of exploratory laparotomy and the systematic tabulation of pathologic findings at such operations, have demonstrated that surgical ailments of the duodenum and the stomach are more than twice as common in males as in females. Many of the ailments which, previous to the extensive resort to laparotomy, were considered, primarily, affections of the stomach or duodenum, have been shown to be gastric upsets, secondary to affections of the gall-bladder, appendix or both. In females, inquiry should be made with regard to the influence of pregnancy and parturition either with respect to the initiation of the dyspeptic upset or their association with periods of exacerbation. In males, note should be made of mental and physical stress, exposure, the habitual or periodic use of excessive amounts of tobacco or alcohol, acquirement of venereal disease, chronic overeating and injuries received as a consequence of occupation or in pursuit of pleasure.

Age.—While surgical affections of the stomach and duodenum may arise at any age, it is safe to say that 75 per cent. of this type of patient comes under observation after the age of thirty. Malignant disease occurs most commonly after the fourth decade of life. It may, however, be observed earlier. We have reported elsewhere 19 cases of gastric carcinoma below the age of thirty-one. Instances have been recorded as early as the tenth year. It need only be mentioned in passing that the majority of surgical affections in infants are likely to have their *anlagen* before birth.

Infectious Diseases.—It is frequently observed that acute infections —influenza, tonsillitis, pneumonia, typhoid fever, parasitic dysentery

and the like—either bear close relationship to dyspeptic attacks or they precipitate such.

The researches of Dieulafoy, Letulle, Chantamesse and Widal, Rodet, Zaidman and of Rosenow furnish significant facts regarding the bearing of local or systemic infection in the production or maintenance of ulceration of the stomach or duodenum. It is more than likely that the toxins associated with local infection or parasitic ailments—diphtheria, tetanus, anthrax—have etiologic significance. The history of chronic infections of the head sinuses and about the teeth may establish primary foci in these localities which may have more than accidental value. The discovery of a chronic pelvic or renal inflammation sometimes proves in part the origin of irritation or ulceration of the duodenum or stomach.

Operative Procedures.—Several years ago we emphasized the fact that in a series of 500 operatively demonstrated ulcers of the stomach, coincident disease was demonstrated in the appendix or gall-bladder or both, in rather more than 50 per cent. of the cases. The experiments of Rosenow would appear to indicate that associated or similar organisms are capable of producing lesions in the stomach, duodenum, appendix or gall-bladder. From studies of histories it would seem that not rarely an infection arising primarily about the mouth, throat or nose, becomes secondarily established in the walls of the appendix or the gall-bladder and that after a varying interval of time such lesion as ulceration follows in the stomach or the duodenum. The significance of early removal of a diseased appendix or gall-bladder upon the subsequent course of an infection of the stomach or duodenum seems worthy of emphasis. Very often the so-called, "hyperacidity syndrome," commonly and carelessly diagnosed as peptic ulcer, entirely disappears following operative procedures upon the appendix or the gall-bladder. Not infrequently, the history of appendix or gall-bladder disease which has not been alleviated by operation, can be obtained for years preceding the definite development of ulcer symptoms.

In instances of dyspepsia which present themselves following laparotomy, it is generally quite important to know whether or not surgical maneuvers have been carried out upon the stomach or duodenum and the exact nature of such. For example, in an instance of suspected carcinoma of the stomach that has seemingly been preceded by a varying term of "ulcer dyspepsia," it is of vital value to know whether or not at a previous laparotomy the ulcer has been extirpated, has been infolded or cauterized, or simple gastro-enterostomy has been performed with or without closure of the pylorus.

Gastric Malfunction.—The presenting complaints generally require close analysis. The acuteness of symptoms associated with dyspepsia or the evidences of hemorrhage or shock may be so pronounced as to mask the nature of the underlying pathologic process. While the immediate disability may require prompt treatment, unless one has a clear conception of the possibilities in the clinical variation of lesions of the stomach or the duodenum, proper measures for permanent relief are

impossible. Careful inquiry must be made into the events that have led up to the presenting signs and symptoms. This should be done in an orderly sequence: the story of the ailment should be developed from the time of the first departure from gastric health. Experience will demonstrate how frequently patients who claim a dyspepsia existing for a few months or years, can cite earlier periods of ill-health if their memories are awakened by intelligent questioning. The history-taker must particularly scrutinize disabilities styled "cramps," "congestive chills," "bilious attacks," "sour stomach," "nervous dyspepsia," "bloody flux," "peritonitis," "ptomain poisoning," "rheumatism of the stomach," etc., etc. Such terms are often fanciful but usually can be translated readily into terms of clinical pathology, involving the stomach, duodenum, gall-tract or appendix, if proper effort be made.

Pain.—This symptom causes fully 90 per cent. of dyspeptic patients to seek relief. In all instances its *location* should be determined. This can be best discovered by having the subject indicate with the hand the areas of distress. While positions of the digestive viscera vary, yet, in general, lesions of the stomach or the duodenum give rise to *epigastric discomfort.* Except in acute disturbances (penetrating ulcer or cancer, obstructions, rupture and the like) surgical ailments of the stomach or duodenum rarely evidence well defined areas of pain: the zone of distress is usually moderately widespread without points of pronounced maximum severity. When the peritoneum has been attacked, however, well circumscribed spots of pronounced pain can be delimited. *Radiation of pain* is not without diagnostic significance. Except for transmission to the back (between the shoulders or the tip of either scapula or to the lower thoracic or the upper lumbar sections of the spine) or the rib margins, pain associated with gastroduodenal disease is usually local. Observation of this fact aids in segregating ailments of these portions of the alimentary tract from those of a pain-producing nature associated with lesions of the gall-tract, appendix, kidneys, pancreas, diaphragm, or the nervous or vascular system (central or spinal cord disease, embolism, thrombosis, aneurysm).

Time of Pain.—Distress associated with the act of deglutition commonly points to affections of the esophagus or the cardiac end of the stomach. Not rarely, pain immediately after the swallowing act indicates types of gastric spasm dependent upon hyperesthesia of the mucosa or pathologic processes at or near the pylorus or located extragastrically, as in the duodenum, gall-bladder or appendix. In ulcer of the duodenum or the stomach, pain-time may vary in different attacks. While the rule does not uniformly hold true, in general, uncomplicated ulcers of these portions of the viscera give rise to distress from two to six hours following the ingestion of an ordinary meal, *i. e.*, when the stomach is emptying or nearly empty. Night pain (from 12 M. to 2 A.M.), when periodically recurring, is fairly regularly a manifestation of duodenal or pyloric ulcer. Complicated lesions (ulcer, cancer) give rise to more or less constant distress, not uncommonly punctuated with

phases of exacerbation. It would seem that such are due to extensions of the lesion, hemorrhage, sloughing or perforation.

Duration of Pain.—A striking feature of distress concomitant with benign abdominal pathology producing gastric symptoms is what may be termed its "periodicity." Until complications (stenoses, malignancy, perforation or peritoneal involvement) have taken place, pyloric irritability in association with ulcer of the antral end of the stomach or of the duodenum or with disease of the gall-bladder or appendix, generally occurs in "attacks" or "spells." There is usually good gastric health in the interim. These attacks of a periodic nature not uncommonly have seasonal relation (spring and fall being favorites). They would seem to be associated in some way with extension of infective processes or to reinfection of tissue whose defensive mechanism has been previously damaged. The nature of the underlying pathology causes these recrudescences or "attacks" to be chiefly self-limited in their duration, although this factor varies greatly with the individual. Chronic gastric and duodenal ulcers, of the uncomplicated type, manifest "periodicity" so constantly as to warrant this feature of the symptomatology as being of much diagnostic significance. It was present in 82 per cent. of 1700 operatively demonstrated gastric and duodenal ulcers which were analyzed by the writer. These recrudescences are generally clean-cut—each like its predecessor in its main features—until complications ensue. The duration of the disability varies considerably in the various attacks, though the chief manifestations are similar. The appearance of a dyspeptic storm of a type unusual to the given individual who previously has had definite and like attacks, usually means that the pathology of his ailment is altering and complications may be expected. In chronic sufferers, complications such as stenosis, peritoneal invasion, hemorrhage or malignancy may be looked for. In primary malignant disease but rarely is the patient granted periods of freedom from his dyspepsia: the ailment is generally continuous, and perniciously and progressively downward in character. The development of gastric malformation or obstruction due to the activity of benign lesions is always associated with continuous gastric malfunction of some form. The dyspepsias associated with chronic gastroduodenitis, primary achylia gastrica, disease of the liver, gall-tract, blood-vascular system or kidneys are generally continuous and only rarely intermittent.

Character of Pain.—The distress associated with open ulcer of the stomach or the duodenum is commonly described as "burning," "sore," "raw," "sticking," "gnawing" or "dull, heavy ache." When ulcers rapidly extend and involve the peritoneal coats, invade adjacent organs, are in or near the gastric orifices, undergo malignant transition or are complicated by hemorrhage, the abdominal distress is mentioned as being "boring," "stabbing," "piercing," or "cutting." It is often sudden and acutely prostrating, causing the patient to double up—lie over a pillow—go into shock or seek relief from local heat, lavage or opiates. Prostrating pain in the course of an ulcer-dyspepsia speaks

most commonly for peritoneal invasion, protected perforation or hemorrhage. Incorrectly, this type of abdominal distress has been too frequently described as the characteristic pain of peptic ulcer: it is the pain of a complication in the course of gastric ulcer—be such acute or chronic. The pain associated with well established gastric malignancy is generally spoken of as "heaviness," "dull ache," "feeling of weight or lump," "bloated sensation." However, acute exacerbations with intense suffering are not rare.

When stenoses have developed, the gastric distress is described as "fulness," "heaviness," "distention" and "suffocation." If the tone of the stomach walls remains strong, "grinding," "scraping" or "cramp-like" pains develop as peristaltic activity becomes abnormal.

Pyloric spasm (often associated with disease of the appendix or gall-bladder or both) generally produces right epigastric distress varying from vague discomfort to acute, cramp-like pains that are not uncommonly difficult to differentiate from those associated with active pyloric ulcer. They usually come on immediately or soon after food ingestion and are rarely long-continued. Inasmuch as pyloric spasm may be present with superficial peptic ulcer in the antrum or pyloric channel, when pains of the spasm type are evidenced, one must exclude ulcer before he can ascribe such distress solely to extragastric pathology.

Relief of Pain.—The discomfort associated with simple, uncomplicated peptic ulcer is so uniformly relieved by food ingestion as to render this phenomenon of diagnostic value. Food relief was present in 87 per cent. of the writer's series of peptic ulcer. While patients generally state that eating causes pain, close inquiry will elicit the information that food rarely causes immediate discomfort but that the pain produced (?) appears usually from two to five hours *post cibo*. As a rule the greater the bulk of the meal the longer delayed is the onset of pain. When such comes on, then food ingestion commonly brings about cessation of distress. Often patients learn this fact and keep themselves comfortable by frequent munchings of crackers, biscuits, chocolate, etc. When stenoses, adhesions or malignant transition ensue, food relief of distress is rarely complete. The discomfort is then constant and relief is generally secured by partial starvation, (diet), alkalies, lavage, vomiting, frequent belching, catharsis and, in about 14 per cent., by opiates. In a given case, the disappearance of food relief, with the necessity for relief of discomfort by some of the agents above mentioned, speaks for a change in the type of the previously existing lesion. Every effort should be made to early determine the pathologic nature and the extent of this change.

Vomiting and Nausea.—In the course of a chronic dyspepsia, nausea and vomiting are symptoms of prime diagnostic importance. Intermittent vomiting generally indicates pyloric or cardiac spasm. These spasms are usually associated with ulcer near the orifices or infective processes in the gall-tract or the appendix. There is a coincident gastritis or duodenitis. The vomiting occurs commonly soon after food ingestion or several hours later when food is leaving the

stomach, acidity is high or pain is experienced. The vomitus in such instances is composed of food making up the meal just eaten, sour gastric juice and frequently partly oxidized bile.

When stenoses in the gastric or duodenal lumen have been produced by the development of hypertrophic muscle layers, ulcer-scar, or neoplasm, then regular vomiting occurs if the patient remain on a bulky diet. Keeping a dyspeptic on "baby food" may for a long time mask a stenosis or, where one is known to exist, may lead to a cessation of vomiting and thus give rise to the opinion that diet or some form of medication is bringing about cure of the ailment. The establishment of a full-meal schedule promptly precipitates vomiting and proves the true state of affairs. Where stenoses are pronounced and food intake of even moderate quantity, then gastric dilatation and stagnation lead to the appearance of "*delayed vomiting.*" In this event, food that has lain in the stomach for eight or more hours is vomited quite regularly. Morning or late evening vomiting is quite common. The amount vomited may be at times strikingly copious, and seemingly far in excess of the quantity of food ingested. The vomitus is generally made up of poorly chymified food, strings or gobs of mucus, and has a foul, yeasty (benign retention) or a peculiarly penetrating, rancid or rotten odor (malignant retention). With the few exceptions of extreme gastroduodenal atony, persistent "delayed" vomit always signifies some obstruction to the free onward progression of food: thus proof of the occurrence of retention vomiting is an important point diagnostically.

Constant *nausea* is not infrequent in gastric malignancy. It may be the only symptom. Its persistence should always urge careful scrutiny of the causes of the dyspepsia from every angle. Except in instances of dietetic error (professional banqueting, alcoholism) and certain physiologic states (pregnancy, catamenia) morning nausea commonly indicates gastric stagnation (ulcer, neoplasm). The nausea associated with gall-tract disease, achylia, intestinal stasis, or cardiorenal disease is apt to be intermittent. Hemorrhage may produce nausea and if the bleeding is not profuse or sudden, signs of shock may be lacking and unless the stools be examined the cause of the nausea may long go unexplained. Pyloric relaxation, with free regurgitation of duodenal contents into the stomach, may result in distressing and obstinate morning nausea. This cause of nausea is of frequent occurrence as a sequel to operations performed upon the stomach, duodenum, gall-bladder or appendix.

Hemorrhage.—Under "Gastric Hemorrhage" is a discussion of this sign (page 612). Unless bleeding from the stomach or the duodenum has been copious and accompanied by evidences of shock, its occurrence may readily escape the patient's notice and may be missed in casual history-taking. Special inquiry should be made respecting the appearance of unusual symptoms during dyspeptic attacks: unaccountable nausea, or sweating, with or without pain, dizziness or fainting, passage of dark-colored or even black stools when no medicine (bismuth, iron, tannic acid, etc.) is being given, unusual weakness or pallor following

an attack of dyspepsia similar in other ways to those previous. Gross gastric hemorrhage is of more common incidence in peptic ulcer of the stomach or the duodenum than it is in frank malignancy. Where neoplasm exists, constant seepage is the rule. Vomiting of blood is usually indicative of a gastric lesion, but not necessarily so. Duodenal ulcer situated near the pylorus may be attended by copious hematemesis. Melena alone may occur in ulcer or cancer located in any portion of the stomach wall, but persistent melena without hematemesis generally points to a pyloric or postpyloric lesion. In a chronic dyspepsia, associated with cardiorenal or liver disease or blood dyscrasia (cirrhosis of the liver, leukemia, Banti's syndrome, etc.) gross hemorrhage is not infrequently observed. It may be an initial sign and for a time may cloud the diagnosis. Toxic, gastric hemorrhage, whether due to drugs, poisons, burns or biochemical products arising within the body, frequently arouses suspicion that a primary lesion is located in the stomach wall. Gastrorrhagia following abdominal operations may be a puzzling and alarming complication. Vicarious hemorrhage, associated with nervous instability or anomalies of the genital apparatus, may lead to unnecessary operations upon females.

Weight.—Persistent weight loss, other things being equal, speaks for malignancy or for starvation due to painful peptic ulcer, stenoses, irrational dieting or drug taking. Malignancy is always accompanied by weight loss, steadily maintained and generally early associated with evidences of cancer intoxication unless ascites or edema complicates. Intermittent weight loss is common in attacks of dyspepsia of the peptic ulcer type, but until complications have occurred (stenoses, adhesions, perforation, severe hemorrhage, etc.) weight gain is usually rapid in the periods between attacks. The weight loss of benign ulcer is, however, rarely accompanied by indications of cachexia.

Appetite.—Benign lesions of the stomach or the duodenum are frequently accompanied by loss of appetite during attacks. This may be due to dread of bringing on pain by eating, by fear of producing hemorrhage, by partial or complete fasting according to dietetic instructions, or as result of intragastric conditions (stagnation, bile regurgitation, alterations in the secretions of the digestive glands). Between attacks the appetite is usually very keen and may induce to overeating. Malignancy is early accompanied by appetite diminution. There may be failure of desire or aversion to all food. Not rarely the appetite is capricious—salt, sour, highly-seasoned or unusually-flavored viands being craved. The distaste for meats or meat-products or of sweets may be manifested very early, in fact, may be the cause for directing the patient to a physician. As gastric stagnation develops, be the lesion malignant or benign, the appetite is generally much reduced. The vomiting known to be induced by free feeding, not rarely leads to a poor-appetite habit. Change in the kind of food may promptly lead to desire approaching normal.

Bowels.—Constipation was observed in more than 60 per cent. of instances of benign peptic ulcer in our series. Its history not infre-

quently preceded that of the ulcer dyspepsia. In some cases, however, it would seem that constipation is in a measure due to the lack of a normal variety or quantity of food as a consequence of persistent and often entirely irrational "dieting."

An attack of uncontrollable diarrhea may usher in malignant disease of the stomach. For weeks it may be the only hint that something is wrong. Constipation is the rule. It seems to depend upon limited food intake, muscular weakness of the walls of the gastro-intestinal canal and alteration in the quantity and kind of digestive juices. Periods of diarrhea may alternate with those of constipation. Infrequent stools of a diarrheic type are not uncommon. These often contain poorly digested food, disintegrated blood, great numbers of bacteria, mucus and atypical crystals. When the pancreas has been invaded by a neoplasm, diarrheic stools exhibiting creatorrhea and steatorrhea are common.

PHYSICAL EXAMINATION.

Patients should be properly prepared for examination. They should be stripped, whenever possible, but need not be shocked by unnecessary exposure. The study should be made under favorable surroundings. The examining room should be light, warm and quiet. A comfortable table should be provided, one on which the patient may lie at ease, yet the table should not be so wide or so high as to make it difficult for the examiner readily to carry out his manipulations.

A general, physical examination should always precede the study of regions of suspected disease. This is especially to be urged in instances of abdominal ailments. So often does disease of the stomach, duodenum, gall-bladder, liver, appendix, etc., seem to have etiologic relation to injections about the head sinuses, the mouth and throat that much significant information may be missed if these localities are not carefully scrutinized. Not infrequently anomalies which make themselves manifest mainly by gastro-intestinal symptoms and signs, can be shown primarily to depend upon intrathoracic disease, if routine examination of the chest be made. The physical *status præsens* should always be supplemented by such information as can be derived from chemic, serologic, roentgenologic or microscopic analyses of body fluids, secretions, excretions, tissues and the regional study of special organs.

Preparation of Patient for Abdominal Examination.—Except in acute ailments, the hollow viscera should be emptied before being studied. Accumulations of gas and feces frequently interfere with the securing of exact information. This fault is prevented by administering 2 ounces of castor oil from eight to twelve hours before the patient comes to the examining room or is visited. In some cases of marked intestinal stasis, enemata of warm soapsuds and water, glycerine and salts, or molasses and milk may be necessary to completely empty the colon. If there are indications that gastric stagnation exists, then lavage by means of a large-caliber tube (Fig. 247), with an abundance of warm water

should be performed. While the stomach-tube is still in position, the viscus may be inflated with air, by the aid of a double-bulb, Davidson syringe. By this maneuver, valuable facts relative to the size, shape, position and abnormalities of outline (tumors, adhesions and the like) of the stomach may be secured. With a soft-wax, colored pencil, points of interest may be directly indicated upon the abdominal wall.

Inspection.—*General.*—The patient's physical attitude frequently indicates the presence or absence of disease. This attitude may vary greatly as the patient is examined during an acute exacerbation of

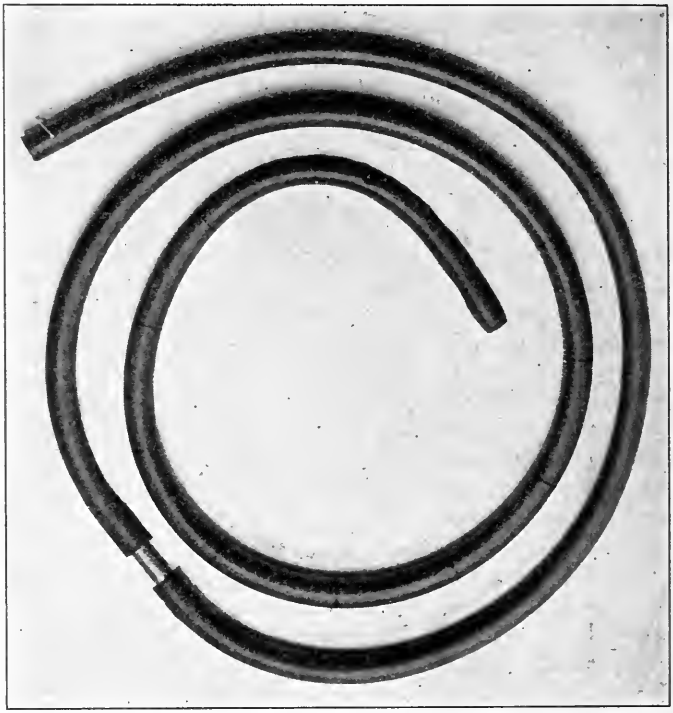


FIG. 247.—Motor meal and lavage tube (Smithies type). Full view of tube, showing segments, markings and fenestra on distal segment and aluminum mid-piece. Segments separated to show this.

his illness, or in a period of quiescence. This is especially the case in chronic ulcer where the ailment is characterized by "periodicity." In acute ailments, where the peritoneum has become involved, extension of the disease has occurred to adjacent organs, during the passage of a gall-stone, or in instances of marked spasm at the cardia or pyloric orifice, the patient may be found doubled up, bent over, pressing a pillow against the epigastrium or writhing about on the floor or in bed, as the result of pain. Not infrequently profuse perspiration, pale, drawn face, agonized look, dyspnea, or cries of distress indicate the severity of the discomfort. After a severe

hemorrhage, the patient may lie in a dead faint, with cold, clammy, pale skin, dilated pupils, sighing respiration and with flabby muscles. Where the gall-bladder or peritoneum has been involved by infection, the subject may be found in an actual chill with or without jaundice, or, later on, with a high temperature. In instances of malignant disease or in benign ailments where there has been an obstruction to the free onward progression of food, the patient may be caught during an attack of vomiting or of severe nausea or retching.

In both benign and malignant disease associated with obstruction, evidences of weight loss can readily be seen. The weight loss in benign affections may be as marked as in those where malignancy is present, but as a rule patients with well established malignancy exhibit not only evidences of starvation, but also those of cancerous intoxication. Such are noted in the shuffling gait, collapse on sitting in a chair or lying on a table, breathlessness on exertion, pale, muddy, or sallow skin, absence of subcutaneous fat on cheeks, neck or over the body, lusterless eye and dry mucous surfaces. Not rarely, traces of edema are observed about the ankles, and occasionally anasarca is noted.

Visible glands should be searched for. These are most commonly seen, in instances of malignancy, above the left clavicle, about the navel and in the inguinal region. Such glands are usually discrete, but may be confluent. They rarely ulcerate.

Special Abdominal Examination.—The contour of the abdomen may vary markedly. In cases where such affections as chronic ulcer of the duodenum or stomach exist no abnormality may be noted. Where obstruction at the cardia, or of the lumen of the stomach or duodenum, has become marked not rarely the evidence of starvation is shown by the abdomen being flat or scaphoid. If the obstruction is at the pylorus and of high degree, should the muscle tone yet be good, visible peristaltic waves may be observed to run from the left rib margin across the epigastrium to the right. More rarely, waves of reverse peristalsis can be seen passing slowly from the right side or in the region of the pylorus, leftward, across the epigastrium.

After there has been much weight loss associated with lack of tone in the abdominal muscles in instances of marked pyloric stenosis or hour-glass stomach, the much dilated or distended stomach may be seen lying in the mid-abdomen. In cases where the pyloric obstruction is due to malignant disease the normal tone is early lost. In such event, while the much distended stomach is visualized, it is uncommon to observe visible peristalsis. Only very uncommonly can waves of reverse peristalsis be noted.

Where there has been involvement of the portal circulation, extension of disease (malignant or benign) to the peritoneum, or obstruction to the lymph-stream, the well rounded abdomen with bulging in the flanks or in the dependent portions, should the patient stand erect, indicates accumulation of fluid. This well rounded, abdominal contour is frequently in striking contrast to the evidences of emaciation seen elsewhere. The skin over such abdomens may be tightly stretched

and present a mottled, reddish blue, or brawny appearance. Sometimes, greatly distended superficial veins and venous capillaries are seen, and where the circulatory obstruction has been long continued, general edema may be noted. In instances of thrombosis of the portal vein, its radicals, or the veins in the mesentery, localized plaques of edema and discoloration can be made out in various portions of the abdominal wall.

Tumors.—These may result from a filled and distended stomach or bowel, a neoplasm involving portions of the gut, liver, kidneys, pancreas, retroperitoneal tissues, omentum, abdominal aorta, mesentery, spleen, or the structures forming the abdominal wall.

Gastric tumors are usually seen above the navel: in fact, 92 per cent. of all tumors lying above the navel are associated with the stomach and the duodenum. Gastric tumors usually move upon respiration, inflation of the stomach or the colon with air, and not infrequently upon change of the patient's position. These points frequently serve to differentiate such growths from those involving the adjacent abdominal viscera. Large tumors of the stomach may be hidden by their position (fundus, posterior gastric wall, lesser curvature, beneath the ribs, or behind the liver), by accumulations of abdominal fluid, or by thick, edematous parietes. Metastases of malignant growths primary to the stomach, may be noted in the enlarged liver, through the omentum, about the navel and in the inguinal nodes. Not infrequently, accumulations of material in the stomach and bowel, especially in emaciated or neurotic individuals, make it extremely difficult to say that these organs are not the seats of tumors. In such instances, it is of the greatest importance, as we have emphasized above, that the examination be made only after thoroughly emptying the abdominal viscera. In acute ailments of the stomach or the duodenum, or in acute exacerbations occurring in the course of chronic affections, the abdominal wall may be so rigid or distended as to prevent visualization of parts which, if seen, might otherwise indicate the disease. In these instances, the examination is greatly facilitated by having the patient lie for from fifteen minutes to a half hour in a bath with the water at a temperature above 100° F.

Palpation.—General palpation gives useful information regarding the body temperature, the state of the skin (cold, clammy, the skin of shock; hot, dry, the skin of fever; loose, inelastic, dry, wrinkled, the skin of cachexia and starvation), the thickness of the subcutaneous fat, or diminution in tone of the skeletal muscles. A careful search should be made for palpable lymph-nodes above the clavicles, in the axilla, or inguinal regions, about the navel or in the rectovesical space. In the absence of blood dyscrasias, such nodes usually point toward malignancy and generally a malignancy of inoperable extent. General anasarca or traces of edema about the malleoli as a rule point to grave disorders.

The tension of the abdominal wall is usually markedly diminished in cases of malignant disease where there has not occurred an accumulation of ascitic fluid. Where there is a large volume of fluid in the

peritoneal sac, the tension of the abdominal wall may be enormously increased. Where there has been perforation of acute or chronic ulcer of the duodenum or the stomach, general or localized zones of increased tension aid one in roughly delimiting the extent of peritonitis.

In late gastric cancer an abdominal *tumor* was palpable in more than 71 per cent. of 921 cases which the writer studied. In but few instances was the tumor located below the navel. It was usually in the mid-epigastrium or to the right, and as a rule could be moved about by the palpating hand to some extent. Such tumors generally varied in size from that of a common marble to as large as a baby's head. Only rarely were they very tender to the touch, the palpating fingers usually causing but vague discomfort. Generally such tumors are made up of multiple nodules, but at times they may be smooth and easily outlined. There are instances where it is very difficult to be sure whether or not an epigastric tumor is connected with the stomach, pancreas, gall-bladder, liver or the omentum. The gastric tumors as a rule, however, are associated with a more definite gastric history than are tumors in other locations, and with the exception of tumors of the omentum are more freely movable. After inflation of the stomach with air, gastric tumors may be noticeably displaced or may vary greatly in size.

Abdominal Tenderness.—In chronic affections of the stomach and the duodenum, definite points of abdominal tenderness are largely dependent upon whether or no the patient is examined during a period of extension or recrudescence of his disease. If the former exists, then local areas of distress upon moderate pressure may be readily outlined. Unless the peritoneum has become involved, however, these areas of tenderness are rarely small. As a rule there is diffuse, epigastric muscle-spasm associated with added spasm of distress in certain sections of the general zone. It is a mistake to expect that palpation will definitely outline points of abdominal tenderness which have locations with respect to certain portions of the stomach or the duodenum. In but a general way, can palpation of a zone of tenderness in the right upper quadrant indicate that the duodenum is involved, if such tender point is taken in connection with a clinical history of the duodenal ailment. The course of the normal duodenum varies so greatly that tenderness in the right upper quadrant may be in no way related to the anatomic position of the duodenum in a given individual. These facts readily can be proved by outlining areas of tenderness over what are thought to be parts of the stomach or duodenum, and then examining the patient by means of the fluoroscopic screen. It will be found frequently that the points of tenderness supposed to be over these viscera have no relation whatever to such upon fluoroscopic examination. These observations indicate how misleading and fruitless it is to attempt definitely to locate position, in the stomach or the duodenum of ulcer or cancer, by placing reliance upon the locations of tender areas upon abdominal examination. Unfortunately masses of statistics with respect to the location of ulcers or cancers of the duo-

denum or stomach have been tabulated after this fashion. Mention is made of them here only to point out their utter uselessness.

It is true that fully 60 per cent. of gastric ulcers lie in the pyloric fourth of the stomach, and fully 80 per cent. of the duodenal ulcers lie in the first third of the duodenum. It is also true that in the majority of individuals these portions of the viscera are situated above the navel or to the right side of the epigastrium. A knowledge of these facts, coupled with a certain amount of imagination make it not a difficult thing for an examiner to prophesy that in a patient with a typical ulcer history, the lesion is in the stomach's pyloric fourth or the proximal third of the duodenum. It is absolutely impossible, however, for one to say before laparotomy or autopsy whether the ulcer is on the duodenal or the gastric side of the pylorus, unless the physical examination is supplemented by that by the *x*-ray. Even then, those most expert are often in doubt.

In an abdominal crisis, dependent upon accident in the course of disease of the duodenum and the stomach, unless the patient is seen very early, the rapid extension of peritoneal involvement may prevent localizing the original process by abdominal palpation. Very often the patient's subjective description of his earliest pain is of greater aid in localization than is the information obtained by abdominal palpation.

Where acute exacerbation, in the course of a chronic duodenal or gastric affection—ulcer, carcinoma—has occurred (perforation, fistula, severe hemorrhage), there is generally an attempt made to wall off the infection by rapid formation of peritoneal adhesions. This occurs generally in all instances of perforation where the ulcer or cancer is not located on the anterior wall of the viscus. Palpation, in these circumstances usually discloses a normal abdomen excepting for pain and increased tension in rather definite areas of the epigastrium. With the history, this anomalous finding of a locally "acute abdomen" existing in a portion of a "chronic abdomen" is of great diagnostic significance.

Rectal Examination.—This never should be neglected, particularly in cases giving the history of melena, chronic dyspepsia of the ulcer type, diarrhea, obstinate constipation with painful passage of stool, or where the physical examination points to malignancy. Not infrequently, rectal examination will demonstrate that so-called melena is due to bleeding hemorrhoids, ulcerations of the rectum or sigmoid (parasitic, specific, tuberculous, malignant, or in association with diverticula), new growths, foreign bodies, varicosities as a result of displacement of the pelvic organs, or to chronic interference with the portal circulation.

Metastases.—Metastases in patients affected with malignant disease of the stomach or adjacent viscera are palpable quite early in the rectovesical space. There they form a collection of nodules of various sizes that lie close behind the bladder. These are readily palpable at the end of the examining finger as a sort of ledge or shelf-like protrusion, to which Blumer has given the name of the "rectal shelf." In late instances of the disease, the entire rectovesical space may be filled

with firm, discrete or confluent masses. It is of particular importance to identify these nodules, inasmuch as when they are present, radical operations for the cure of malignant disease of the stomach are out of the question in so far as permanent relief from the disease is concerned. Even if by wide dissection it is possible to remove the disease from the stomach wall, and, mechanically, a perfect operation can be performed, yet on account of the scattering of cancer cells throughout the lymph-stream, recurrence is sure to take place within a short time.

Percussion.—When the stomach has been filled with fluid or air, light percussion enables one to outline the relative size and position of the viscus. Indications of dilatation of the stomach are supplied by the estimation of the distance between the outlines of its lesser and greater curvatures, and not entirely by the demonstration of the location of the greater curvature. When the normal stomach is inflated, the average distance between the lesser and greater curvatures, in the midline, is rather more than 3 inches. In instances of dilatation, as result of pyloric obstruction or of marked gastric atony, the distance between the two curvatures may be as great as eight to ten inches. The relationship of neither of the curvatures to the umbilicus indicates definitely either the size of the stomach or whether or not it is in "normal position," or is ptosed. Slight experience will demonstrate the variation in the position of the umbilicus with regard to bony skeletal landmarks. Many hugely dilated stomachs do not descend below the patient's navel, whereas numerous instances of stomachs with normal capacity can be demonstrated where the stomach is wholly below the navel.

It is of but slight significance, diagnostically, to percuss the outline of a *gastric tumor,* but considerable information regarding the size and position that such tumor occupies in the stomach wall can be derived by percussing the outline of such tumor-dulness before and after inflation of the stomach with air. Not rarely, posterior wall or deep lying tumors along the curvatures are lost after gastric inflation, but in many cases, examination with the stomach empty will enable their ready demonstration. It is not uncommon to have the pyloric half of the stomach noticeably rotate as the stomach is filled with air. In this way, tumors which could not be outlined before inflation are thrust forward against the anterior abdominal wall and their outlines can then be percussed in definite relationship to the stomach. If, after inflation of the stomach, the outlines of the liver and other solid abdominal viscera are determined by percussion, it frequently will be seen whether or no secondary tumors have arisen in the liver, pancreas or omentum, especially if percussion outlines before and after gastric inflation are compared or contrasted.

Accumulation of *ascitic fluid* in the abdomen may entirely mask even extensive gastric tumors, the presence of free fluid being determined by percussing the outlines of dulness with the patient in various positions—lying on the back, sitting, standing, or lying on either side. At times, however, the accumulation of ascitic fluid may be so great as to

result in neither fluctuation waves or the percussion of a movable dulness: the entire abdomen may be dull to percussion.

After paracentesis, and the withdrawal of all or some of the fluid, gastric outlines and tumors connected with the stomach or adjacent viscera may be outlined.

Auscultation.—This maneuver is of relatively slight diagnostic value in lesions of the stomach and the duodenum. In instances of great dilatation of the stomach, with retention, splashing sounds can be heard over the stomach many hours after soft or liquid food has been given, if the stomach zone is sharply tapped while the stethoscope lies over some portion of it. One should differentiate such splashing sounds from the gurgling sounds which occur over the bowels of normal individuals, or of individuals of an excitable type who are mentally perturbed over the steps of an examination.

After gastro-enterostomy has been performed, if the patient be directed to drink freely, by listening over the middle third of the greater curvature of the stomach, gurgling or distinct squirting sounds may prove the patency of a gastro-enterostomy stoma. In instances of "hour-glass stomach" the escape of fluids or gas from an upper chamber to a lower, may, at times, be made out by auscultation. Occasionally, splashing sounds in two definite locations, separated by a zone in which no splashing is heard, can be demonstrated. This is particularly apt to occur in instances where a large ulcer or cancer of the saddle type has brought about a tube-like constriction in the middle third of the stomach. In instances of *obstruction at the cardia*, due to partial stenosis as result of chronic ulcer or cancer, if the stethoscope is applied at about the level of the eleventh dorsal vertebra, posteriorly, in the midline, and the patient directed to swallow a glass of water, the second swallowing sound may be either greatly delayed, imperfectly heard or not recognized at all.

To demonstrate the presence or the absence of free hydrochloric acid, it has been suggested that the patient be given a half dram of sodium bicarbonate in a small amount of water. The stethoscope is then placed over the region of the stomach. If hydrochloric acid is present, sizzling sounds can be heard. This test is of but relative value, and certainly has limited practical bearing.

Esophagoscopy and Gastroscopy.—These procedures in the hands of an expert are of considerable diagnostic worth. The esophagus and the stomach should be completely emptied before any instrument of this type be passed. The instruments devised by Sussman of Berlin are of the greatest service. Sussman's apparatus is of flexible type, and can be inserted into the esophagus or stomach with the least discomfort to the patient. For esophagoscopy and gastroscopy, however, it would seem best that the patient be given a general anesthetic, and that the instrument be inserted with the patient lying in the dorsal position with the head low over the edge of the table as in performing tonsillectomy. In well established cancer and ulcer of the lower esophagus or stomach, visualization through the esophago-

scope or gastroscope is not without certain advantages from an educational standpoint or in obscure ailments for the purpose of removing bits of tissue for microscopic study. However, since the development of the roentgen ray, the patient is served practically as well by fluoroscopy or the making of several radiograms as by direct vision of the diseased viscus through instruments passed *per orem*.

METHODS OF EXAMINATION OF GASTRO-INTESTINAL FUNCTION. THEIR INTERPRETATION.

GASTRIC CONTENTS.

In ailments of the stomach and the duodenum, the clinical history and the physical examination are often sufficient to enable one to make correct diagnoses. However, there are numerous instances where the routine anamnesis and *status præsens* give but a hint as to the nature of the disease or fail to tell the extent of an affection known to exist. In such event, not rarely, the absolute diagnosis can be learned from clinical laboratory tests, particularly from physical, chemical, biochemical and microscopic analyses of gastric extracts and of feces. Even in cases where the diagnosis can be roughly made from clinical history and physical examination, one cannot obtain an adequate conception of the abnormalities associated with the ailment without the data that may be secured from intelligent scrutiny of vomitus, stomach contents and feces. On the other hand, caution is to be urged against placing laboratory analyses paramount in the making of diagnoses of ailments of the stomach and the duodenum. Data from such studies should be interpreted rigidly in the light of facts established by the anamnesis and the physical examination. In doubtful instances, it will be found, not infrequently, that more reliance may be placed upon the clinical observations than upon uncommon or novel laboratory tests. Sometimes, however, in obscure cases, *e. g.*, physically inaccessible cancer of the posterior wall or of the fundus of the stomach, test-meal analyses will establish the correct diagnosis in a few minutes.

Investigation of Gastric Emptying Power.—Methods.—The emptying power of the stomach is best estimated by the administration of a physiological meal of mixed food after the patient has been taken off "diet" and his stomach is, as far as possible, empty. Experience has taught us that a twelve-hour time interval is of greater diagnostic worth than the four- to six-hour interval recommended by Riegel and others.

Physiological Motor Meal.—Its object is to demonstrate the free entrance into and exit of ordinary food from the stomach. The meal should be cautiously administered following recent, severe hemorrhage, clinical evidences of ulcer or cancer perforation, coma, extreme physical weakness, delirium, or severe ailments of the heart, bloodvessels or the kidneys.

Method.—Thorough lavage with warm water should completely empty the stomach. Two ounces of castor oil are poured into the stomach through the stomach tube after the lavage. Three hours later

the patient is given a fairly large meal of mixed food. In addition to other viands, the meal should contain 50 grams of meat, 2 leaves of lettuce and 20 raw raisins. (The skins of the raisins should be eaten.) Tea, water, or milk are allowed. After from eight to twelve hours the stomach is emptied and search made for remnants of the meal administered. No food should have been taken in the interim.

The secretory efficiency is determined by means of the Ewald breakfast of second-day bread or the shredded biscuit meal suggested by Dock. In the ordinary case the time limit for removal is fifty minutes after administration. Where clinical symptomatology indicates abnormally rapid emptying power, the stomach is examined from twenty-five to forty minutes after the test-meal has been given. The size and position of the stomach are determined by inflation through the stomach tube, with the patient recumbent. (We use an inflation bulb, expelling one and a half ounces of air at each compression. The boundaries of the stomach are determined by the auscultatory method while the inflation is in progress.)

In the space allotted, only a brief summary of the interpretation of test-meals can be attempted. These observations are based upon the personal analysis of 7041 consecutive gastric extracts. It is difficult to present the work without its being merely statistical. An attempt has, however, been made to emphasize the clinical pointings.

Size of Stomach.—The average capacity of the stomach is 27 ounces in females and 33 ounces in males where dilatation does not exist. In instances revealing dilatation the average capacity in females is 41 ounces and 52 ounces in males. The greatest gastric capacity is associated with non-malignant pyloric stenosis.

The Macroscopic Appearance of Removed Gastric Extracts.—In addition to evidences of gastric retention this observation is not infrequently of significance.

Color.—Traumatic blood was noted in 6.4 per cent. of our cases. Its presence was quite as constant when simple spasm existed at the cardia as when ulceration was present with or without spasm. Its appearance upon lavage had *no consistent relation to any form of gastric disease other than cancer.* Forty-four cases of gastric ulcer had lavage less than forty-eight hours following hemorrhage, and in these cases there was no recurrence of either gross or microscopic bleeding from the maneuver. In the cancer cases (96 per cent. being of the medullary type) traumatic blood on lavage was observed in more than half of 218 consecutive cases.

Bile Coloring.—Various shades of green or yellow were observed in 11 per cent. of the cases in the series. The yellowish shades were the results of straining as a consequence of tubing or occurred in 74 per cent. of the patients who had had previous gastro-enterostomy (seventy-six). The green coloration from bile was noted quite constantly in cases of gastric atony, ptosis with relaxed pylorus, dilatation with or without ptosis, intermittent pyloric spasm, induration about the pylorus due to ulcer or cancer, and from obstruction below the

papilla of Vater. The green shades usually indicated that bile had been present in the stomach for some hours and had become oxidized. In two instances, the growth of a chlorophylaceous mould was mistaken for bile before chemical tests or microscopic examination had been made. In 126 instances the presence of much traumatic blood rapidly hid evidences of bile coloring.

Of the cancer cases, it is interesting to observe that *coffee-colored* or dark-brown extracts were noted in but 19 per cent. *When such were observed the cases were inoperable.* The color of gastric contents was quite as apt to be tan or brownish in partial stenosis with dilatation or atony from non-malignant causes as from cancer. As will be shown below, however, the odor was a fairly reliable differentiating point between the two conditions. There were 314 cases of benign achylia gastrica. In 96 per cent. of this group the *dead-white* color of the gastric extracts, associated with markedly absent chymification, was a characteristic finding.

Odor.—Extracts from normal stomachs have a peculiarly bland and somewhat sweetish odor. Modifications—quantitative and qualitative—in acidity cause variations. In non-retention cases, the sharpness of the sour odor is usually a reliable gauge of the free hydrochloric acid content. In retention cases, high or low free hydrochloric acidity may be masked by the odor from fermentative or putrefactive processes. In 84 per cent. of the cancer group, *acrid, rancid odors* due to volatile, organic acids were almost pathognomonic. In 76 per cent. of the non-malignant retention class (ulcers, gall-bladder disease, or ptosis with or without atony) the *yeasty aroma* was almost similarly characteristic. This simply elicited sign proved in our experience to be extremely useful in differential diagnosis. *Putrefactive odors* are generally due to sloughing of cancer tissue, deterioration of a quantity of blood in the presence of low hydrochloric acidity, fecal contents from obstruction below the duodenum or from perforation of ulcer or cancer into an adjacent viscus.

Amount of Gastric Extract.—The average quantity of test-meal removed in our entire series was 108 c.c. The average quantity in the non-retention group was 76 c.c. The average quantity in the retention class was 350 c.c. So-called "hypersecretion" was as frequently observed in pyloric spasm from appendix or gall-bladder disease as from duodenal or gastric ulcer. It is not difficult to mistake partial pyloric stenosis for irritative hypersecretion. But 21 per cent. of the non-stenosing ulcers (duodenal or gastric) exhibited what might be termed hypersecretion. In young adults of both sexes the most common cause of hypersecretion was pyloric spasm due to diseased appendix or gall-bladder. Some degree of such was constantly present if the symptoms had persisted longer than an average time of 2.8 years.

Mucus.—Mucus is a sign of doubtful diagnostic worth. It is more commonly in excess in stenosing cancers or ulcers than when the pyloric channel is free. While but 1 per cent. of hyperacidity and hypersecretion cases were associated with pathological increase in mucus, 46

per cent. of the malignant retention group and 29 per cent. of the benign retention class revealed such increase.

Chymification.—Chymification is an index of masticatory thoroughness, of the character of food ingested, of the combining power of hydrochloric acid, of the presence of normal gastric ferments, and of variations in gastric peristalsis and emptying power. The last factor appears to carry the greatest weight in all cases except those of primary or secondary achylia. While high hydrochloric acid content generally assures good chymification, the presence of organic acids and foreign microorganisms (as in gastric cancer) frequently accomplishes similar ends.

The Incidence of Retarded Gastric Emptying Power.—This term "emptying power," is purposely chosen. "Hypermotility" should be largely limited to what is indicated by "hyperperistalsis." It does not necessarily follow that hyperperistalsis is associated with increased or even normal rate of the stomach's emptying. In fact, our records demonstrate that hyperperistalsis is most commonly found in instances of pyloric spasm or pyloric stenosis which have gastric or extragastric foundation.

Of our entire series, 12 per cent. of the cases showed some grade of retarded gastric emptying power macroscopically. In 8 per cent. of the series this was a *constant* finding. In 4 per cent. it was an intermittent manifestation. In 87 per cent. of the group when gastric retention was a persistent observation, some degree of gastric dilatation was an associated complication. In 2 out of every 3 cases where this occurred there was clinical history of delayed vomiting. Persistent demonstration of gastric retention is an indication for surgical intervention. It denotes mechanical abnormalities or obstruction. In these instances, dilatation of the stomach is a sign and not the disease. In a given case the degree of gastric retention may vary markedly according as the stenosis is or is not associated with gastric or pyloric spasm. Dilatation of the stomach may likewise vary greatly in degree.

In our series the *causes of persistent gastric retention* were, in the order of the frequency of their demonstration, gastric cancer, duodenal ulcer, gastric ulcer, cholecystitis with adhesions, gastric atony, tumor of the pancreas, tumor of the liver, hypernephroma, tuberculous peritonitis, and retroperitoneal sarcoma. The *causes of intermittent gastric retention* were pyloric spasm associated with appendicitis or cholecystitis, gall-stones, duodenitis or gastritis in the presence of increased free hydrochloric acid, and gastroptosis.

In gastric cancer, emptying power was retarded in more than 70 per cent. of instances, irrespective of the location of the growth. In surgical duodenal ulcer, approximately 2 out of 3 cases revealed gastric stagnation. In surgical gastric ulcer in rather more than 50 per cent. of instances some grade of retention was proved. Of the pyloric spasms (associated with appendicitis, cholecystitis, gall-stones, or duodenitis), in rather more than 3 per cent. of instances retention was demonstrated. *The sign of differential worth in this class of case* is that of the variability

of the exhibition of retention at different examinations. This sign is of special value to the surgeon who contemplates gastro-enterostomy in such instances. Unless definite obstruction exists at or near the pylorus the best operative results are only to be expected when artificial stricture is surgically produced. We have records of the examination of 482 cases of pyloric spasm with intermittent gastric retention, when later the appendix had been removed or operations upon the gall-tract had been performed. In but twenty-one instances was any form of gastric stagnation demonstrated postoperatively.

These observations of the incidence of gastric retention, cannot in any way be compared with such information returned from examination by means of the roentgen ray. It should be urged that, in the method outlined, we are dealing with physiological problems. No one has yet shown that the examinations of gastric function by means of bismuth or barium compounds with the aid of the roentgen ray is physiological. Consequently, only a long series of observations that have been checked up by surgical procedure or by the subsequent history in medical cases, extending over several years' time, will enable actinologists to formulate statements that will indicate what meaning we can attribute to retention of bismuth or barium in the stomach at the end of, say, a six-hour interval.

The most common *causes of increased rate of emptying* of the stomach in our series occurred in conjunction with achylia gastrica (primary or associated with severe anemia), vagus hypertonia, temporary or permanent atony without marked gastric dilatation, non-obstructing gastric cancer or syphilis, colitis, and in numerous nervous states of the young adult.

Gastric Acidity.—During the past five years, attempts have been made to belittle the significance of estimations of gastric acidity. This attitude has been brought about largely because of the persistence of surgical teachings. It is to be expected that those who anticipated that a simple color test would serve in place of clinical cerebration would be doomed to disappointment. While we have been compelled to revise some of our previously held opinions regarding the diagnostic worth of acid estimations of gastric extracts, yet when considered as a part of evidence making for proper conception of disease, it would seem that such information can in no wise be neglected. The confusion has arisen chiefly because it was not until recently shown just what effect upon gastric physiology had extragastric disease. Consequently, the findings in disease extrinsic to the stomach were interpreted, clinically, in the light of known primary gastric ailments.

For the purpose of brevity we would classify our acidity findings into three groups: (1) that comprising recognized disease of the stomach itself; (2) that including lesions of the duodenum, gall-bladder, appendix, and the large bowel; (3) that comprising so-called "functional" or central disturbances.

Acidities were all estimated by the Toepfer method, as follows:

Tests for Estimating Gastric Acidity.—When sufficient amount of gastric extract is available, quantitative estimations should be made upon the filtrate. Unfiltered gastric contents return readings higher than when analyses of filtered extracts are made.

"Free" Hydrochloric Acidity.—Method.—Place 10 c.c. of gastric filtrate in a white porcelain evaporating dish. To this add 2 drops of a 0.5 per cent. alcoholic solution of dimethylamidoazobenzol. If HCl is present, the mixture becomes cherry red. The acidity is neutralized by slowly adding from a burette solution of $\frac{N}{10}$ sodium hydroxide. The end point is reached when the mixture in the evaporating dish takes on a lemon yellow color. The number of cubic centimeters (or parts thereof) of $\frac{N}{10}$ sodium hydroxide required to bring about this color change is read from the burette. This figure, multiplied by 10, gives the free HCl acidity per hundred parts. If acidity percentage is desired, the resultant figure is multiplied by 0.00365.

"Total" Acidity.—Method.—Place 10 c.c. of gastric filtrate in a white porcelain evaporating dish. Add 2 drops of a 1 per cent. alcoholic solution of phenolphthalein. There is usually no color change unless the total acidity is low or the extract alkaline. $\frac{N}{10}$ sodium hydroxide solution is added to the mixture from a burette. When the total acidity has been neutralized by the soda solution, the contents of the evaporating dish become pinkish or purplish red. The degree of acidity is computed in the manner employed in estimating "free" HCl.

"Combined" Acidity.—Method.—As an indicator a 1 per cent. watery solution of alizarin is employed. Ten cubic centimeters of gastric filtrate are placed in a white porcelain evaporating dish. Two drops of the alizarin solution are added. The mixture is titrated against $\frac{N}{10}$ sodium hydroxide solution until the fluid is colored violet. Quantitatively the estimations are made as in the analysis for free HCl.

Lactic Acid.—Tests for lactic and organic acids generally, are frequently positive in gastric retention contents, and particularly when malignancy is the cause of the stagnation.

Method.—Six drops of *liquor ferri sesquichlorati* are added to 3 drops of 95 per cent. solution of carbolic acid. This mixture is diluted with distilled water until it assumes a lively amethyst-blue color. To this last solution, are added 5 to 10 drops of gastric filtrate (or the ether extract of such). If lactic acid is present, the amethyst-blue color is discharged and a canary-yellow color is seen.

Volatile Fatty Acids.—Method.—Five cubic centimeters of gastric filtrate are placed in a test-tube of 20 c.c. capacity. Over the mouth of the test-tube are placed two strips of moistened litmus paper: red and blue. The gastric filtrate is then slowly heated over a Bunsen flame. If volatile fatty acids are present, the blue litmus paper over the test tube mouth turns red as the fumes react upon it. The original strip of red litmus paper acts as a control.

Tests for Altered ("Occult") Blood.—See under Examination of Feces, page 591.

GROUP I.—ACIDITY IN INTRINSIC GASTRIC DISEASE.

(*a*) Acute gastritis:		
Average—Free HCl		32.0
Total acidity		50.0
Combined acidity		18.0
(*b*) Chronic gastritis:		
Average—Free HCl		42.0
Total acidity		62.0
Combined acidity		14.0
(*c*) Chronic atrophic gastritis:		
Average—Free HCl		12.0
Total acidity		21.0
Combined acidity		9.0
(*d*) Achylia gastrica:		
Average—No free HCl		
Total acidity		8.0
Combined acidity		6.0
(*e*) Gastric ulcer—acute:		
Average—Free HCl		64.0
Total acidity		78.0
Combined acidity		12.0
(*f*) Gastric ulcer with recent hemorrhage:		
Average—Free HCl		35.0
Total acidity		48.0
Combined acidity		13.0
(*g*) Chronic non-retention gastric ulcer:		
Average—Free HCl		42.5
Total acidity		55.0
Combined acidity		13.5
(*h*) Chronic gastric ulcer with retention:		
Average—Free HCl		56.4
Total acidity		74.2
Combined acidity		17.8
(*i*) Chronic perforating ulcer:		
Average—Free HCl		64.1
Total acidity		76.2
Combined acidity		12.0
(*j*) Ulcus carcinomatosum—(64 cases):		
Average—Free HCl		33.4
Total acidity		51.0
Combined acidity		16.0
(*k*) Primary gastric cancer—(122 cases):		
Average—Free HCl		7.4
Total acidity		28.3
Combined acidity		21.0
(*l*) Ulcerating primary gastric cancer (14 cases):		
Average—Free HCl		2.0
Total acidity		34.0
Combined acidity		30.0

SUMMARY.—*Group I.*—It is shown that the highest gastric acidities are uniformly determined in acute and subacute perforating ulcer of the stomach; that in simple, chronic gastritis the picture from the standpoint of acidity closely resembles that of *ulcus carcinomatosum* or of simple gastric ulcer when recent bleeding has occurred; that only 54 per cent. of cases of gastric cancer reveal absent free hydrochloric acid; that in 45 per cent. of instances of gastric cancer the acidity returns may be readily confused with those of simple gastric ulcer, chronic gastritis, or achylia gastrica unless the figures are rigidly interpreted in the light of clinical history, etc.; that in gastric ulcer with

retention there is an increase in both free hydrochloric and total acidity, which fact is in sharp contrast to instances of retention developing in gastric cancer, in which event, as retention comes on, free hydrochloric is progressively lowered, while total acidity simultaneously increases. Other things being equal, in a given case, the diminution of free hydrochloric associated with an increase in total acidity, with the development of obstruction and the demonstration of organic acids, speaks for malignancy.

GROUP II.—ACIDITY WHERE THE LESIONS ARE MAINLY OUTSIDE THE STOMACH.

(*a*) Duodenitis with pyloric spasm:	
Average—Free HCl	68.0
Total acidity	74.0
Combined acidity	6.0
(*b*) Duodenal ulcer without stenosis:	
Average—Free HCl	59.2
Total acidity	73.0
Combined acidity	14.0
(*c*) Duodenal ulcer with stenosis:	
Average—Free HCl	46.0
Total acidity	84.0
Combined acidity	28.0
(*d*) Cholecystitis, subacute:	
Average—Free HCl	66.0
Total acidity	71.0
Combined acidity	5.0
(*e*) Cholecystitis, chronic:	
Average—Free HCl	32.0
Total acidity	46.0
Combined acidity	14.0
(*f*) Appendicitis, subacute or chronic (usually in young adults both sexes):	
Average—Free HCl	64.0
Total acidity	75.0
Combined acidity	8.0
(*g*) Colitis, subacute or chronic:	
Average—Free HCl	35.0
Total acidity	42.0
Combined acidity	7.0
(*h*) Following gastro-enterostomy for gastric or duodenal ulcer:	
Average reduction in free hydrochloric acid	17.0
Total acidity	32.0
Combined acidity	12.0

SUMMARY.—*Group* 2.—Of this division the highest free hydrochloric acidities are present in cases of pyloric spasm associated with subacute cholecystitis, appendicitis and duodenitis. The figures closely resemble those returned in gastric ulcer, as does also the clinical history with the exception of the incidence of hemorrhage, chemical proof of bleeding and the time factor. The onset of stenosis in duodenal ulcer increases combined acidity at the expense of the free hydrochloric acidity. After gastro-enterostomy for non-malignant stenosis there is a consistent and noticeable lowering of free hydrochloric and also total acidity, which cannot, apparently, be wholly explained on the basis of regurgitation of *succus entericus*. In more than three out of four such instances, proof of this having occurred, can, however, be demonstrated by ferment tests or microscopic examination of stained smears.

GROUP III.—FUNCTIONAL AND CENTRAL DISTURBANCES.

(*a*)	In epilepsy of the young adult:	
	Average—Free HCl	56.0
	Total acidity	62.0
	Combined acidity	5.0
(*b*)	In neurasthenia, with or without moderate gastroptosis:	
	Average—Free HCl	34.0
	Total acidity	46.0
	Combined acidity	9.0
(*c*)	In marked gastroptosis:	
	Average—Free HCl	37.0
	Total acidity	52.0
	Combined acidity	14.0

These figures interpret themselves and require no special comment.

The demonstration of altered or occult blood in gastric extracts by the benzidin or the guaiac tests was possible in 25 per cent. of the cases in the entire series. It was present in 42 per cent. of all retention cases irrespective of the causative lesion. It was demonstrated in 75 per cent. of 712 cases of gastric cancer. It was almost as frequently shown in duodenal as in gastric ulcer. It would seem that apart from the association of occult blood with malignant processes, its demonstration in gastric extracts has very slight diagnostic worth.

The Incidence and Significance of Organic Acids in Gastric Extracts.—These are rarely demonstrated in non-retention cases, either malignant or non-malignant. In malignant disease, associated with partial stenosis and gastric dilatation, lactic acid was present in 53 per cent. of 712 operatively demonstrated instances. It was rarely demonstrated when free hydrochloric acid rose higher than 10, and in 92 per cent. of cases where lactic acid was found, extensive growths, generally inoperable were present. Only 3 per cent. of the non-malignant achylias were associated with lactic acid. In but 7 per cent. of the non-malignant retention cases was lactic acid present. It was found in less than 0.5 per cent. of instances of ptosis with atony.

Volatile fatty acids were present in 61 per cent. of the malignant cases and in but 3.2 per cent. of the instances of benign retention or atony. In no instance of non-retention or of simple achylia or hypoacidity were volatile fatty acids demonstrated.

The Significance of the Demonstration of Specific Ferments in Gastric Contents.—Space does not permit our going into detail respecting the incidence and diagnostic worth of proving the absence or presence of pepsin and rennin in gastric extracts. It would seem that proteolysis is closely associated with the presence of free hydrochloric acid so long as the acid concentration is below 0.4 per cent. and that milk-curdling ferment follows similar laws. In malignancy, peptolysis appears to be increased at the expense of proteolysis.

Edestin Test ("Peptic Index") of Fuld and Levison.—According to these investigators the peptic power of gastric juice in cancer of the stomach is diminished. Confirmatory observations have been made by Schryver and Singer. Edestin is very difficult to obtain pure, com-

mercially, but may be made in a well equipped laboratory. Schryver and Singer's modification of the original test is as follows:

Method.—A pure preparation of edestin may be obtained in the laboratory by recrystallization from warm salt solution. From this is made a solution of 0.1 per cent. of edestin in 0.12 per cent. hydrochloric acid (*i. e.*, 30 c.c. normal HCl in 1 liter distilled water.) (Such a solution of edestin need not be made freshly for each observation, but, if used as stock, it must be stored at zero temperature.) Into each of 10 small test-tubes 2.5 c.c. of this solution are pipetted and left to take the temperature of the room (10° to 20° C.). Into each test-tube are now dropped 0.1, 0.2, 0.3, 0.4, . . . to 1.0 c.c. (in ascending series) of the gastric juice under investigation, previously diluted to one-tenth of its natural strength. Each test-tube is shaken and left to stand. After thirty minutes have elapsed 0.3 c.c. of a saturated solution of sodium chloride is added to each tube. If digestion has proceeded to a certain point, the solution remains clear, while with lower degrees of digestion a white cloudiness immediately develops.

The Peptic Index in any case is designated as the number of tenths of a cubic centimeter of a diluted juice added to the first clear test-tube and divided into 100. This gives as a range of possible readings the ten numbers 100 (*i. e.*, 100/1), 50 (*i. e.*, 100/2), 33 (*i. e.*, 100/3), 25, 20, 17, 14, 12, 11 and 10. For greater accuracy intermediate amounts of diluted gastric juice may be added, as 0.125, 0.150, 0.175 (between 0.1 and 0.2) etc., but with practice it becomes possible to read such intermediate numbers without recourse to actual experiment. The average of healthy cases is about 50. Cases do occasionally present themselves with an index above 100 (*i. e.*, in which even the test-tube containing only 0.1 c.c. of diluted juice remains clear on the addition of the salt solution). In such instances recourse must be had to the use of more diluted juice. At the other extreme, however, it is seldom necessary to take readings below an index of 10 (*i. e.*, in which even the test-tube containing 1.0 c.c. of diluted gastric juice develops cloudiness on the addition of salt solution), for in such cases our experience seems to show that digestive power is probably almost absent.

This test appears to be a valuable supplementary procedure where the gastric extracts indicate that malignant transition of an ulcer may be present.

We have examined 108 cases for proteolytic ferments by the edestin method, suggested by Fuld and Levison. The results thus far would appear to indicate that early cases of cancer of the stomach, where the free hydrochloric acid is shown to be low, reveal high peptolysis and low proteolysis. In the simple ulcers both peptolysis and proteolysis are low.

We have made observations upon 827 instances of gastric disease for the detection of specific ereptases of malignant ulcer. We have used the formaldehyde titration method as suggested by Sörenson and Schiff. In our experience the average *formol titration index* in 87

instances of proved gastric cancer was 22.3; the average index in 22 cases of *ulcus carcinomatosum* was 19.8; the average in 99 cases of duodenal ulcer was 12.4; of 57 cases of simple gastric ulcer 11.6; of 32 cases of benign achylia, 14.1; of 16 instances of pernicious anemia, 14.5; and of 5 cases of cancer of the liver 4.25. It would appear that in certain instances the estimation of the ereptic power of gastric juice toward peptone solutions is of considerable value when interpreted in the light of clinical history and symptomatology.

Glycyltryptophan and Tryptophan Tests.—In rather more than 40 per cent. of our proved cases of cancer (186) the reaction was positive. In about 7 per cent. the tryptophan test was positive. Diagnosis of malignant disease of the stomach was in each case quite possible, independent of the chemical test. While gastric abnormalities other than cancer exhibited positive glycyltryptophan reactions, in no class of the disease of the stomach was the test so frequently obtained as in cancer. Low free hydrochloric acid was frequently associated with positive glycyltryptophan tests, and in more than 50 per cent. of these reactions the gastric extracts contained bile or blood or both.

Wolff-Junghans' Test for Soluble Albumin in Gastric Extracts.—Methods for the estimation of the soluble albuminous products of digestion have frequently been devised with the hope that such might prove of practical service in the differential diagnosis of gastric ailments. Of these methods, the well-known procedure advanced by Salomon, had for a time the greatest vogue. Esbach's reagent and tubes proved, however, unsatisfactory and inaccurate from a clinical viewpoint. More recently the problem has been approached from the practical quantitative side and encouraging work recorded.

Wolff and Junghans report a method for estimation of the amount of soluble albumin in gastric extracts which they claim has given excellent clinical information in Ewald's service at the Augusta Hospital, Berlin.

Theoretically, their procedure has the following basis: In the normal aspirated test-meal there are demonstrable relatively large quantities of soluble albumin by means of precipitating reagents. This soluble albumin appears only through the agency of the gastric enzymes. This fact is proved by testing for soluble albumin a similar test-meal which has been chymified but not swallowed. In such event, only minute quantities of dissolved albumin are present.

The writer tested the gastric extracts of 15 cases of *ulcus carcinomatosum.* In 11 instances (73.3 per cent.), units of precipitable albumin ranged between 200 to 400. In 3 (20 per cent.), 100 units were shown. In other words, of the 15 cases of malignant gastric ulcer, 14 (93.3 per cent.) were either definitely positive or suspiciously so to the Wolff-Junghans test. One case (6.6 per cent.) exhibited below 100 units of albumin. In this group, motor stagnation of some degree was present in 86.6 per cent.

Microscopic Estimation of Gastric Extracts.—Unfiltered stomach contents should always be studied. The examination is of particular

worth in instances of retention. It frequently serves to distinguish the benign from the malignant types.

The "three drop method" is a simple technic for quick, routine study.

Method.—Upon an ordinary glass microscopic slide place three drops of gastric extract about $\frac{3}{4}$ inch apart in a row. To the second drop add 1 drop of Lugol's solution and to the third drop add 1 drop of osmic acid solution. Nothing is added to the first drop. Upon each drop is placed a cover slip and this is pressed down rather firmly. The drops may now be examined with high power dry or the oil immersion lens.

FIG. 248.—Photomicrogram of a gastric residue of benign gastric retention, showing budding yeasts and sarcinæ. Pyloric obstruction caused by peptic ulcer. (Original observation by author.)

In brief, the summary of our work is as follows:

Starch digestion is not a constant index of the acidity of the stomach juice. Diastatic action of saliva often depends more on motor conditions than upon secretory. The character of the ingested food is a modifying factor. In some instances of low gastric acidity, with normal motility, it would seem that an anti-diastase were present in gastric extracts.

Microscopic remnants of the motor meal have no diagnostic significance other than that indicated when found in association with retained food, macroscopically.

The Diagnostic Significance of the Microörganisms in Gastric Extracts.—From our studies we have developed four microscopic pictures which seem almost pathognomonic for certain types of disease. Apart from these we can see nothing very significant. Certainly high gastric acidity by no means insures bacteriological cleanliness.

Complex 1.—That of Benign Gastric Retention (usually ulcer).—In 89 per cent. of our cases of this type the presence of large numbers

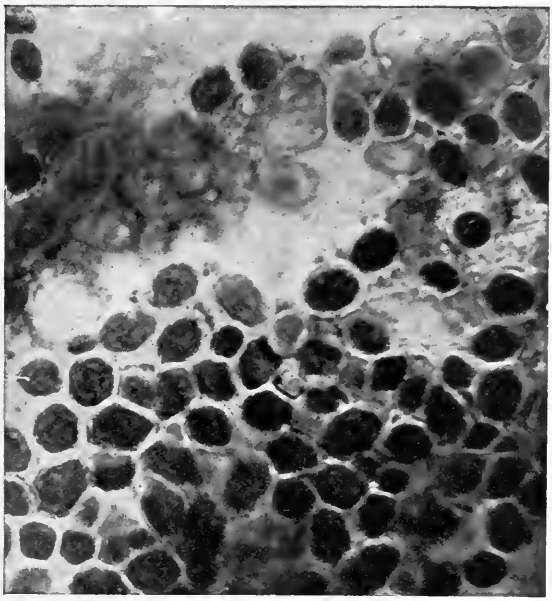


FIG. 249.—Photomicrogram of gastric residue of benign retention (peptic ulcer), showing tile-like pattern formed by great yeast colonies. (Original observation by author.)

of actively budding yeasts, associated with large and small sarcinæ and bacilli, apparently of the colon group, and food bits were demonstrated. The gastric acidity was generally above 50 (Figs. 248 and 249).

Complex 2.—That of Gastric Cancer.—In 93.8 per cent. of all our proved, late, malignant cases, organisms of the Oppler-Boas group, associated with food retention and HCl averaging below 10, was a characteristic picture. In but 30 per cent. of instances were budding yeasts concomitant. In but 10 per cent. were sarcinæ associated. Threads of streptococci were found in 6.2 per cent. (more commonly in the non-retention cases). There is no characteristic microscopic picture of early gastric cancer other than that associated with gastric ulcer of the retention type. In less than 1 per cent. of our cases of gastric cancer were we able to demonstrate so-called "cancer cells"

with active mitoses. These were all late cases or cases where the cardiac orifice was involved with a sloughing growth (Figs. 250 and 251).

FIG. 250.—Photomicrogram of gastric residue of malignant retention (pyloric carcinoma), showing typical long bacilli of the Oppler-Boas group. Note long, somewhat bent or club-shaped rods. (Original observation by author.)

Complex 3.—Achylia Gastrica.—Primary or Secondary.—In gastric extracts of low or absent hydrochloric acid, when there is atrophy of

FIG. 251.—Photomicrogram of gastric residue of malignant retention (pyloric carcinoma), showing bizarre, attenuated "bacilli" of Oppler-Boas group: half-circles, "shinny-sticks," rings, etc. These are frequent attenuation or involution forms of Oppler-Boas bacilli where malignant, gastric retention of long duration and pronounced degree is present. (Original observation by author.)

the mucosa and where motility is not interfered with, there are found long chains of streptococci (resembling beads of a rosary); groups of

large, deep-staining cocci, and a peculiar, short, fat, acid-fast rod or cocco-bacillus that grows in short chains or pairs, or singly.

Complex 4.—When perforation into an adjacent viscus has taken place in malignant ulcer or primary cancer, or where obstruction has occurred below the duodenum, the picture of immense numbers of thick cocco-bacilli, with or without spirillæ or streptococci, in association with low acidity, retarded food progress and putrefaction, as evidenced by the odor, is shown in more than 94 per cent. of instances.

EXAMINATION OF FECES.

An intelligent analysis of stools is of considerable value to both internist and surgeon. If the analyses are not intelligently made, then the facts returned are clinically of little worth. In surgical disease of the stomach and the duodenum the significance of certain special tests should be emphasized. It is not always absolutely necessary to perform all of these tests in order to arrive at a diagnosis of the ailment under investigation, but it cannot be denied that the routine performance of these analyses not only at times give information impossible to obtain in any other way, but conveys a clearer conception of alterations taking place in disease.

Methods of Examination.—Except in special cases (after severe acute hemorrhage or other emergencies) proper preparation of the patient should precede stool examination. The preparation should be governed by the type of investigation that one has in mind. For example, the preparation for tests used to demonstrate the presence or absence of altered blood in the stools differs from that carried out in the attempt to estimate the digestive capacity of the pancreas or the liver. As routine, all forms of medication should be interdicted during the time that specimens of stool are collected. Unless this caution is remembered the stool examination may be useless or harmful deductions may be derived from the result of laboratory tests.

Macroscopic Examination of Feces.—Much information may be derived from intelligent inspection of freshly passed stools.

If little food is entering or passing from the stomach as result of stenoses, the stools are likely to be small in quantity, of very fine consistency and are often covered with tenacious mucus. Where the bile tract has become involved by a neoplasm or a fibrous stricture, clay- or putty-colored movements are frequently seen. If the pancreas has been invaded (penetrating ulcer, cancer, cyst), the stool may be large in quantity, putty or gun-metal colored, pasty, greasy, foamy or fatty, contain much unaltered food (gobs of fat—butter-like or egg-yolk appearing—or chunks of undigested meat, milk-clots or vegetable tissue) and have a foul, musty, sour, acrid, penetrating odor. When fistulous tracts have developed between the stomach and bowel, macroscopic blood, necrotic tissue, pus or mucus may be noted. Black or red stools follow extensive hemorrhage.

Diarrheic stools result from faulty diet or imperfect function of

stomach, liver, pancreas or small bowel. They may accompany severe hemorrhage. In pronounced asthenia, cardiorenal disease, neuroses, or organic nervous disease, diarrheic stools may be persistent or occur at irregular periods. Infectious ailments (miliary tuberculosis, typhoid fever, bacillary or protozoic dysentery) commonly cause systemic wasting associated with diarrhea. In atypic instances of malignancy of the stomach or bowel, it may be difficult to rule out such as the primary cause of the loose stools.

Color.—The color of stools varies widely. After severe gastric or duodenal hemorrhage, red, black or greenish movements often mixed with fleshy clots or spongy masses of blood may be passed for several days. Green, tan, cream, yellow or putty-colored stools are not uncommonly observed in ailments involving viscera in the upper abdomen. In serious disease of the pancreas, foul-smelling, bulky, asbestos-colored stools, greasy with unsplit fat, are almost pathognomonic.

Chemical Examination of Feces.—*Reaction of Feces.*—Healthy stools are commonly faintly acid or amphoteric. Malignancy of the stomach or pancreas is frequently associated with very alkaline feces.

Bile pigment in feces is recognized conveniently by the *Schmidt bichloride test.*

Method.—Intimately mix 5 grams (or 10 c.c. in case the stool is fluid) of feces in about four times its volume of saturated solution of bichloride of mercury. This can be done in a small mortar. Allow to stand five minutes after mixing. Pour off the supernatant fluid into a Petri dish; cover, and let stand from two to twenty-four hours. *Hydrobilirubin* is indicated by the fluid assuming a salmon to deep red shade. If olive green change occurs, *biliverdin* is present.

This test is of especial worth in instances where light-colored stools are passed, and disease of the stomach secondarily invading the liver, pancreas or gall-ducts is suspected.

Demonstration of Altered or "Occult" Blood in the Stools.—The patient's intestinal canal should be first completely emptied by the administration of 2 ounces of *oleum ricini* or a bottle of citrate of magnesia. The patient should then be given a diet free from meat or its products or an excess of green vegetables, for two days. On the third day nothing but milk or cereal gruel should be given. On the morning of the fourth day, a half bottle of citrate of magnesia should be administered, and the second stool passed collected and sent to the laboratory in a covered vessel for analysis.

Tests for "Occult" Blood.—Numerous tests are in vogue. If the stool has been properly collected and the tests carefully performed, they are all of worth clinically. On account of abortive reactions, not infrequently given by the use of poor preparations of aloin, guaiac or phenolphthalein, routinely, it has seemed that benzidin solutions have returned the most reliable information. The pinkish-gray powder should be used, and this should be kept in a brown bottle, carefully stoppered.

The benzidin test is performed as follows:

Benzidin Test.—A standard solution of benzidin for use may be made by dissolving one gram of pure benzidin powder in 50 c.c. of 95 per cent. alcohol. If this solution is preserved in a brown glass-stoppered bottle and not kept in a very warm place it will remain dependable. Other reagents necessary for the test are glacial acetic acid, pure ether and a fresh solution of hydrogen peroxide.

The test is set up as follows: Into a test-tube of 15 to 25 c.c. capacity are placed 3 c.c. or one gram of feces. To this are added 5 to 10 drops of glacial acetic acid. The tube is thoroughly shaken. Next are added 5 to 10 c.c. of pure ether. An intimate mixture is obtained by pouring the contents of the tube into another, and *vice versa*, several times. The mixture is allowed to stand a minute or two until the clear ether layer separates at the top. This ether layer is poured off into another clean test-tube. To this ether extract are added 15 to 30 drops of the 2 per cent. solution of benzidin in 95 per cent. alcohol. The mixture is thoroughly shaken, and finally are added 15 to 30 drops of hydrogen peroxide. The tube is again shaken. If blood pigment has been present in the feces, even in as great dilution as 1 to 12,000, its presence will be indicated by the fluid assuming a lively emerald-green color that rapidly gives place to deep ultramarine. This color change should occur within one minute. If there is not a decided color change within this time, in our experience, color changes occurring later can be safely discarded as being of no clinical significance.

Interpretation of Positive "Occult" Blood Tests.—A positive response to chemical test for blood in the stool only signifies that there is a bleeding point somewhere between the lips and the external anal ring. It is thus evident that tests should be rigidly controlled and interpreted strictly in relation to the clinical history of the case. Positive tests are most commonly *constant* in malignancy. They are *intermittently* present in the stools from chronic, recurring peptic ulcer.

The *negative test* for "occult" blood in feces is of aid in excluding malignancy, particularly in instances where, with a dubious clinical history, an atypic, abdominal tumor can be demonstrated.

Ferment Tests in Feces.—The main worth of these lies in gaining knowledge respecting the function of the pancreas. This function may be seriously limited by disease from the stomach or duodenum which has extended to the gland (ulcer, cancer, etc.). Feces prepared by the administration of Schmidt's test diet[1] are commonly analyzed for the presence of diastase and tryspin. Special methods, requiring expert

[1] Schmidt test diet:

MORNING, 8 A.M. ½ liter (500 c.c.) parboiled milk (or if milk disagrees, ½ liter cocoa made from 400 c.c. water, 100 c.c. milk, 20 grams cocoa powder 10 grams sugar) and 3 pieces toasted Graham bread with 1 ounce butter.

FORENOON, 10 A.M.: ½ liter oatmeal gruel (40 grams oatmeal, 10 grams butter, 200 c.c. milk, 300 c.c. water), 1 egg poached, 2 Graham crackers.

NOON, 12 o'clock: 125 grams chopped beef (raw weight), broiled rare, with 30 grams butter, and 250 grams potato broth (made of 190 grams mashed potato, 100 c.c. milk and 10 grams butter).

MID-AFTERNOON, 3 P.M.: Same as morning (8 A.M.).

EVENING, 6 P.M.: Same as forenoon (10 A.M.).

skill and care in their manipulations are necessary. The technics devised by Wohlgemuth and by Gross-Wynhausen are dependable. Space does not permit the rather elaborate procedures being given here. They are fully outlined by Cammidge,[1] whose work should be consulted by clinicians especially interested.

Microscopic Examination of Feces.—Only specimens of the *freshly passed* stool give reliable information. They should be arranged for examination, by the "three drop method" (see above under Gastric Extracts, page 586) stained with methylene blue or by colored agar.[2] For the observation of motile organisms, unstained feces, diluted with warm normal salt solution, are examined.

ROENTGEN EXAMINATION.

With the aid of the roentgen ray, information of considerable diagnostic worth may be added to the clinical analysis of surgical diseases of the stomach and the duodenum. To obtain the best results, a proper technic must be followed, and if roentgenograms are made, they should be interpreted by an expert. If all interpretations are made in the light of clinical history and physical and laboratory data, a well-balanced picture of disease may be secured. However, the roentgen method of examination is not infallible. If other clinical findings are positive, approved methods of treatment should not give way to negative or doubtful roentgen reports. Whenever possible, the clinician and the actinologist should work in close coöperation: certainly the clinician should study radiograms and observe fluoroscopic examinations, if for no other purpose than to compare such shadowgrams with operative disclosures and physical findings.

Methods.—The patient should be prepared for roentgen examination of the alimentary tract so as to have his hollow viscera as nearly empty as possible. If the clinical history indicates gastric stagnation, the stomach should be emptied by lavage. The bowels may be freed of their contents by the administration of from 2 to 4 ounces of *oleum ricini* twelve hours before the patient appears for study. In special instances an enema may be required. No food, or only small quantities of liquids, should be given after the purge or the lavage.

The roentgen examination has for its objects: (1) the demonstration of the patency of the gastric orifices and of the lumina of the stomach and the duodenum; and (2) the visualization of abnormalities in their contour, position, size, mobility, relation to adjacent viscera or the presence of foreign bodies within them. With exception of the search for foreign bodies, these objects are attained by the introduction into the viscera of substances opaque to the roentgen ray. Commonly, mixtures or suspensions of pure bismuth subcarbonate or oxychlorid, or of barium sulphate are employed. Occasionally the viscera or the peritoneal sac are distended with air or with gas. Necessary obser-

[1] Feces of Children and Adults, W. Wood & Co., 1915.
[2] Smithies: Arch. Int. Med.

vations are made during examination with the fluoroscopic screen or from shadows cast upon photographic plates or films. Each type of examination has its own value and each should supplement the other, particularly in doubtful cases.

Fluoroscopic Examination.—Numerous types of dependable apparatus are upon the market. The essential requirements are a high-grade water-cooled or Coolidge tube, a first-class fluoroscopic screen and adequate protection for both patient and operator. With the recently devised apparatus for controlling the Coolidge tube, many observations may be made within a short time without the inconvenience of frequently changing tubes and with the minimum of breakage.

Estimation of the Patency of the Gastric Orifices.—*The Emptying Power of the Stomach.*—To prove whether or no the stomach is able to free itself of contents, a motor meal is administered. After an arbitrary time interval (usually six hours) has elapsed, the abdomen is fluoroscoped and definite note is made of the position of the previously administered motor-meal.

Many types of motor-meals are used. A convenient meal is composed of 8 ounces (cooked weight) of lump-free cream of wheat, to which are added from 5 to 7 ounces of pure bismuth oxychlorid, bismuth subcarbonate or barium sulphate. The mixture should be as intimate a one as possible. It is best to remove all lumps or to finely divide them by trituration. A meal may be rendered more palatable by the addition of fruit-juice flavors, cream and sugar. It should be administered when the patient's stomach is known to be empty and the patient should be instructed to eat or drink nothing until after the fluoroscopic examination.

Information Derived from Observations of the Fluoroscopic Motor-meal.—In cases where there is mechanical interference to the onward progress of food (hour-glass, benign or malignant stenoses, diverticula, crater formations, marked or persistent muscle spasms or fistulæ) varying quantities of the motor-meal administered six hours previously may be demonstrated as *residue* in the stomach. Not infrequently, definite organic stenoses are aggravated by the coincidence of spasm of the stomach or the duodenum, and in such event a condition of complete obstruction may apparently exist which at later observations, particularly after the administration of belladonna or atropin, is disclosed as partial stenosis with partial stagnation. This following up of the evidence secured by the demonstration of gastric residue is quite essential if one wishes to be sure of the degree of obstruction that may be demonstrated at laparotomy. Unless this is done many surprises are in store for those roentgenographers who place absolute reliance upon six hour residues as indication of anatomic stenoses. Frequently, marked spasm at the cardia or the pylorus, or in the course of the duodenum, and more rarely, in the course of the stomach itself, result in six hour motor-meal residues. Especially in this type of case should frequent observations be made, particularly

after the administration of atropin or of belladonna. In this fashion, one can readily segregate instances of retention due to spasm alone from those where retention is dependent upon anatomical faults.

In cases of marked general or local æsthenia, at times, persistent six hour gastric residues may be demonstrated, where at laparotomy no organic obstruction can be found. In these cases, manipulation during the fluoroscopic examination usually proves that the orifices are patent, inasmuch as the motor-meal or the succeeding suspension of an opaque fluid meal, can be forced readily through the cardia or the pylorus.

The amount of motor meal remaining in the stomach after six hours is a rough index of the degree of obstruction at the pylorus, provided one eliminates from the consideration the possibility of stenosis complicated by added spasm.

Local residues are sometimes discovered in pockets formed by malignant or benign disease, diverticula, fistulæ, or in the diverticula-like pouchings, associated with marked bilocular or multilocular *hour-glass stomach.*

Observations should be made of the position of that portion of the motor-meal which has left the stomach. In the normal individual, at the end of six hours, the portion of the motor meal that first left the stomach, can be demonstrated in the terminal ileum or the proximal sections of the colon. Occasionally the meal may have advanced as far as the sigmoid or the rectum.

Duodenal Retention.—Duodenal retention is less common than is gastric retention as demonstrated by the opaque motor-meal. Where there is obstruction in the first part of the jejunum, or in the second part of the duodenum, or where crater-ulcer or perforation to adjacent viscera exists, flecks or irregular bits of opaque mixture may be seen. Where marked stenosis of the duodenum is present, as result of ulcer and its complications, a residue may remain within the stomach, which residue is associated with no demonstrable gastric pathology, but secondarily results from the duodenal stenosis. Not rarely, partial duodenal stenosis is associated with marked duodenal spasm, and in such cases, gastroduodenal residue may be out of all proportion to the extent of the actual lesion discovered at laparotomy.

Observations of the Physical Contour of the Stomach and the Duodenum.—This examination is made fluoroscopically while the patient's stomach is *being filled* with an opaque meal and *after* the opaque meal has been taken, completely filling the viscus.

Opaque Meals.—These are mixtures or suspensions of bismuth oxychlorid, bismuth subcarbonate or of barium sulphate. Many types exist, but the essentials for a meal to serve its purpose properly are that the consistency be not too thick, that the meal be palatable, and that the shadow-casting ingredients remain in good suspension.

For outlining the pyloric zone, noting the irregularities of the duodenum before pyloric spasm has interfered with the proper filling of the duodenum, and for locating small irregularities in gastric or in duodenal

contour (crater-ulcer, adhesions, fistulæ, etc.), a suspension of from 2 to 4 ounces of an opaque substance in 16 to 20 ounces of warm water is very useful. The patient swallows this rapidly and special attention is directed toward the contour of the pyloric zone and the first half of the duodenum immediately upon the meal being swallowed, and before pyloric or duodenal spasms have prevented the complete filling of the lumen.

Immediately after this meal has been taken and proper observations recorded, a careful study of the stomach and duodenum is made when these viscera have been completely filled by a second opaque meal. This second meal is of thicker consistency than the first and is of larger quantity. A satisfactory meal consists of potato starch paste ($1\frac{1}{2}$ liters) to which have been added malted milk (30 grams) and from 6 to 8 ounces of bismuth oxychlorid, bismuth subcarbonate or barium sulphate. The ingredients must be thoroughly mixed, preferably with an egg beater. Before the meal is given to the patient the whole mass should be strained through a flour sifter. The meal may be flavored with vanilla, chocolate or fruit juices, if desired. The fluoroscopic observations should be made in a systematic manner and along the lines indicated below.

(*a*) *Form.*—When the normal stomach has been completely filled out by an opaque medium, it will be seen roughly to resemble a "fish hook" (common female type), "steer horn" (male type) or various possible combinations of both types. When interference has occurred to the free, onward progress of food, the stomach may be bag-shaped, globular, gourd-shaped, bottle-like, or loculated. Various types of "hour-glass" are possible as a consequence of the presence of ulcer, cancer and their complications.

(*b*) *Size.*—There is much latitude in the size of the normal stomach. Very large stomachs may result from gastric atony, persistent pyloric spasm and pyloric and duodenal obstructions. Extremely small stomachs are not rarely associated with obstruction at the cardia, the growth of neoplasms either extending into the gastric lumen or developing in the walls of the stomach (syphilis, cirrhosis, tuberculosis), or are normal at different ages (infancy, childhood and old age).

(*c*) *Position.*—The female stomach lies roughly vertical, its longest diameter being grossly parallel with the spinal column. The normal male stomach generally assumes the oblique or approximately horizontal position across the epigastrium. Adhesions, involvement of portions of the stomach by disease in adjacent viscera, or from the extension of ailments primary in the stomach or the duodenum to other abdominal organs, may greatly displace the stomach from its so-called "normal" position. Sometimes the stomach and the duodenum are displaced by a large liver, a tumor of the kidney, pancreas, retroperitoneal tissues, a large spleen, ovarian cyst, pregnancy or the accumulation of fluid in the peritoneal sacs. Change of position of the patient generally modifies the position of both the stomach and the duodenum. The "normal" position of the duodenum

varies widely. Sometimes it extends well to the right under the liver, again it turns sharply backward and runs posterior to the stomach. Not rarely it descends almost vertically from the pylorus, or may go anteriorly and loop irregularly in the region of the pylorus. This normal variation in the position of the duodenum should be recognized, as it renders extremely questionable the association of tender points, upon abdominal palpation, with relation to their location upon definite portions of the duodenum itself.

(*d*) *Contour.*—Persistent irregularities in gastric outline are usually evidences of gastric ulcer, cancer, syphilis or their sequelæ. More rarely the contour of the stomach is altered as the result of disease in adjacent organs: gall bladder, tumors of the liver, pancreas, spleen, colon, left kidney and retroperitoneal tissues. In low-lying stomachs, especially in females, occasionally, pelvic growths or inflammatory processes produce abnormalities in gastric outline.

After surgical operations, variations in contour can be observed, especially where such operations have consisted in resections of ulcer or cancer, infolding, cauterization or compression suturing of ulcers, gastro-enterostomy, etc.

Spasms.—Spasms of the stomach result in local constrictions or indentations (incisuræ). They are commonly found in association with superficial open ulcers, over-activity of the secretory and muscular structures of the stomach and such extragastric ailments as duodenitis or chronic inflammatory alterations in the appendix or the gall-bladder. The essential point in diagnosis is that one should prove that these spasms are not associated with gross anatomic changes in contour. Simple spasm is often transitory, and successive fluoroscopic examinations may prove that the spasm seen at one examination has disappeared, or that spasmodic contracture exists in another part of the stomach. This variation in the location of the spasm or its appearance and disappearance at different examinations, is best demonstrated following the administration of atropine or of belladonna over a period of from two days to a week.

Spasm at the pylorus or at the cardia may be extremely persistent—so persistent as closely to simulate organic lesion at either of these points. Such spasm may be even associated with noticeable gastric retention. It is nearly always found in connection with alterations in gastric peristalsis. Such may be especially marked in cases of pyloric spasm. These stomachs should always be examined several times at two- or three-day intervals and following the administration of atropine, belladonna or benzyl benzoate.

Alterations in duodenal contour are largely dependent upon the development of duodenal ulcer and its associated complications (crater formation, penetration, fistulæ, adhesions). Only rarely does malignancy develop in the duodenum. In a recent analysis of 1200 operatively demonstrated cases of disease of the duodenum, in but seven instances did we note primary cancer. These neoplasms were in close association with the orifices of the bile and the pancreatic ducts.

Malignancy secondary to a primary process in the stomach is not uncommon, but not so frequent as one would think considering the tendency of ulcers of the pylorus to be malignant, and the pylorus itself being so frequently the seat of cancer. The duodenum appears to have an unknown protection against malignant disease. Extragastric disease is at times the cause of abnormalities in duodenal contour. Adhesions between the duodenum and the gall-bladder, gall stones, fibrous bands from the omentum or colon, disease of the right kidney (hydronephosis, perinephritic abscess), abscess or cyst of the liver or pancreas and retroperitoneal tumors may not only cause deformity of duodenal contour, but noticeable displacement.

Spasms of the duodenum are not so frequently observed as they are in the stomach. They are commonly associated with duodenitis, alterations in duodenal reaction chemically, and open, active ulcer.

(*e*) *Mobility of Stomach and the Duodenum.*—Unless fixed by adhesions, commonly associated with gastric ulcer, or by the extension of ulcer or cancer to adjacent viscera, the pyloric half of the stomach is seen to be displaceable upon palpation under the fluoroscopic screen. When adhesions—benign or malignant—have occurred, then not only are definite displacements of the viscus seen, but great limitation in movement or often actual fixation may be encountered. This observation is of much worth, particularly with respect to the prognostic limitation imposed upon an advised surgical procedure.

(*f*) *Peristalsis.*—Normal peristaltic waves appear *in the stomach* within a few minutes following ingestion of the opaque meal. They usually travel with fair regularity toward the pylorus at the rate of from 3 to 5 per minute. When the gastric contour has been interfered with by the development of ulcer or cancer, the regularity of the peristaltic waves, with respect to both rate and intensity, varies greatly. Not infrequently in ulcer, the peristaltic waves are increased in rate and strength, especially if such ulcers be located at or near the pylorus. This *hyperperistalsis* is not without diagnostic significance in cases of non-penetrating ulcers, provided the clinical history of the disease and laboratory data are corroborative. In ulcers located proximal to the antrum of the stomach, local haltings of the normal peristaltic rhythm may result in definite indentations in the stomach wall. These indentations may persist (unless anti-spasmodic medicine is administered) for many minutes, as easily recognized *incisuræ* due to spasm of the circular muscle fibers of the gastric wall. Incisuræ are best observed along the greater curvature in instances of lesser curvature ulcers. They are frequently better brought out by fairly vigorous palpation along the lesser curvature. They should always be checked up with respect to their persistency after administration of atropine or of belladonna.

In malignant disease, the stomach tone, as well as the peristaltic activity, is early diminished in intensity. In well established carcinoma of the stomach it is quite uncommon to observe a definite peristaltic cycle, or even to see any peristalsis. Where there are early

malignant changes in the edges of a chronic peptic ulcer, peristaltic activity may be extremely marked and in such case, roentgenographically, there is nothing to differentiate the ailment from one of benign character. Large gastric tumors, due to syphilis or slowly growing sarcomata, may occasionally be observed in association with vigorous gastric peristalsis. This anomaly is not without considerable diagnostic value because in ordinary circumstances, tumors of the stomach of a cancerous nature are rarely observed in association with vigorous peristalsis.

The peristaltic cycle in the stomach is noticeably interfered with after gastro-enterostomy and the various types of operations for the relief of ulcer and cancer and their complications.

Lesions of the duodenum, particularly ulcer, and especially superficial ulcer or ulcer that has not yet become associated with marked scar tissue formation, early make themselves evident fluoroscopically by marked pyloric spasm. This pyloric spasm of duodenal origin results in a noticeable exaggeration of normal gastric peristalsis. In no non-obstructive lesion of the pylorus is hyperperistalsis so characteristic as that in ulceration of the duodenum of the type described. Fluoroscopically, when taken into consideration with clinical history and other data, is of great weight in clinching a diagnosis.

When benign anatomic obstruction has occurred at or near the pylorus on either the gastric or the duodenal side, provided there has not been such extreme dilatation of the stomach as to result in atony, hyperperistalsis is commonly observed. In rare instances antiperistalsis (peristaltic waves running *from* the pylorus *toward* the cardia) may be recognized.

Study of Special Portions of the Stomach and Duodenum.—A full discussion of the local alterations produced by surgical lesions of the stomach and the duodenum will be introduced under each disease.

Examination of the Stomach and the Duodenum by Means of Plates or by Films.—Due to the conveniences offered by fluoroscopy, it is not now necessary to make radiograms of all cases. By means of the fluoroscopic screen the normal stomach or the duodenum may be viewed, and in this way the labor, time and expense of making plates done away with. If, at the fluoroscopic examination, abnormalities are seen or suspected, then several plates or a series of such may be made at once or during the following twelve to twenty-four hours. In the majority of cases, elaborate plate series are not necessary for clinical diagnosis, however interesting they may prove as experimental studies to the curious.

For the purpose of accuracy, the plate examination should be made only after the patient's stomach has been as far as possible filled with an opaque mixture. After the fluoroscopy, the patient can be given a second liter of the barium or bismuth suspension above described. The stomach is usually completely filled by the second meal and all portions of it penetrated by the opaque mixture. This is quite essential inasmuch as unless the stomach is well filled out, high-lying irregu-

larities, due to ulcer, tumor or abnormalities in adjacent viscera, may escape notice by not being visualized on the roentgen plate. The plate should be exposed at once and at desired intervals after swallowing the meal.

Position of Patient During Plate Examination.—Opinions differ. Some actinologists prefer making plates with the patient standing, while others prefer to make the exposure with the patient lying face downward on the plate. Probably plates made in both positions will give the greatest amount of information. For purposes of special study, the patient may be placed in either the right or left lateral, or in the Trendelenburg positions.

If plate series are made, then the patient should be instructed to eat nothing, or very little, during the entire period covered by the observations.

Interpretation of Roentgen Plates.—On all patients, interpretations should be made by individuals who have knowledge of how the subject was prepared, of how the plates were made, and who has more than a theoretic acquaintance with clinical medicine and surgical pathology. If plates are interpreted after this fashion, then there will occur the minimum of error. While the roentgenographic interpretation should be as nearly as possible objective, yet the ability to translate roentgen abnormalities into clinical terms renders the actinologist a more useful aid to the clinician.

In general, roentgen plates demonstrate alterations from the normal shape, position, size, contour and peristalsis of the stomach and the duodenum, and also give indications respecting emptying power, relations to adjoining viscera and alterations that have been brought about as the result of previous operations. In the following sections, consideration of these variations from the normal in disease will be specified.

PART II.

CONGENITAL ANOMALIES OF THE STOMACH.

Atresia.—Instances of absent gastric lumen are very rare. In such cases, there is commonly imperfect formation of esophagus, duodenum and jejunum. The stomach is represented by a thick fibrous cord, which, histologically examined, may reveal the normal layers of the gastric wall, with exception of the mucosa. This is generally incompletely developed. Specimens showing extremely small stomach lumens are occasionally described. In Heller's case the cavity of the stomach held scarcely a hen's egg. Congenital strictures of the stomach may occur. The cavity of the viscus may be separated into several chambers usually of small capacity. Diverticulum-like pouches sometimes result and persist through life. Atresias are commonly found in the pyloric half of the stomach. Little and Helmholz report such a

case in detail. A mere cord may connect the body of the stomach with the small gut.

Clinical Symptoms.—Infants with pronounced atresias are commonly either born dead or survive but a brief time after birth. They succumb from starvation. Vomiting, constipation, diminished urine output and emaciation suggest lesions of an obstructive type. The vomitus or lavage fluid may be free from bile coloring. Digestive enzymes or hydrochloric acid are commonly reduced or absent. Obstruction to the free passage of a small stomach-tube may be encountered. Gastric lavage may demonstrate contents retained from previous feedings in atypic loculi. Lanugo hairs may be absent from the stools of the young infant. Roentgen examination graphically reveals the shape, size, position and patency of the altered viscus. The stomach may be filled with the opaque meal through a large catheter or a small-caliber stomach-tube.

Prognosis.—The prognosis depends upon the causes of the atresia, its degree and the general condition of the patient.

Contracted Stomach (*Angustatio Ventriculi*).—The stomach cavity may hold but a few ounces. Both secretory and motor functions may be normal. Congenital stricture of the esophagus, failure of the gastric segment of endoderm fully to develop or insufficient general nourishment of the infant may be responsible for the anomaly.

Symptoms.—Clinically, the symptoms and signs are not characteristic. The routine feeding of normal quantities of food may produce obstinate regurgitation and vomiting. The infant fails to gain in weight. Emaciation, with dry skin and mucous surfaces, follows. Constipation and small urine output are common. Roentgen examination, when the stomach has been filled with a barium or bismuth mixture, shows the nature of the affection.

Prognosis.—The prognosis is rarely bright with respect to the future development of a lusty child. Under proper feeding the capacity of the stomach sometimes can be increased. As a life-saving measure gastrojejunostomy or gastrostomy may be indicated.

Pyloric Stenosis in Infancy (*"Congenital Hypertrophic Pyloric Stenosis"*).—**Definition.**—A gastric affection of the new-born, characterized by the presence of a stenosing, pyloric tumor, comprised mainly of hypertrophied muscle tissue. Secondarily, there occur dilatation of the stomach, obstructive vomiting, rapid emaciation, diminution of body fluids, anemia and, unless the pyloric stenosis be early relieved, death from starvation.

Etiology.—*Age.*—The child is born with a narrowed gastric outlet. Symptoms appear just so soon as mouth feeding is begun. The *sexes* are equally affected. Other evidences of congenitally anomalous development may be not lacking. Harelip, cleft palate, club-foot, imperforate anus and the like have been described in association with the pyloric fault.

Genesis of the Stenosis.—Scudder has emphasized that the pyloric tumor represents a congenital, local overgrowth of muscle tissue.

Inasmuch as the pyloric musculature is differentiated before the fourth month of fetal life, it is conceivable that sufficient time elapses before birth for this group of muscle bundles to assume the proportions of a definite tumor previous to the initiation of gastric function. Dent has described such a tumor in a seven months' fetus. Its structure was like that found in cases of hypertrophic stenosis examined after birth. Just what underlying causes bring about such myomatoid change in the pyloric muscle tissue of the fetus, is not known.

Pathology.—A tumor composed mainly of dense, firm, circular muscle fibers involves the pyloric sphincter. According to Scudder the resultant nodule is about the size of the terminal phalanx of an adult finger or thumb. There are no external evidences of inflammatory reaction; the pylorus is free from adhesions. The hypertrophied muscle tissue narrows the lumen of the pyloric channel. It may cause complete obstruction, particularly when there is associated extensive hypertrophy of the longitudinal folds of mucous membrane.

The stomach wall may early appear thickened. It later becomes stretched, thin and atonic. The intestines are commonly empty or poorly filled, their peritoneal surfaces, dry and shiny. The esophagus may be dilated.

Histologically, the pyloric tumor is shown to be made up chiefly of closely packed, hypertrophied bundles of muscle fibers, enclosed in dense, fibrous envelopes. The mucosa is thickened and aberrant. Brunner's glands are sometimes recognized.

Symptoms.—Unless other gross congenital anomalies exist, the infant appears normal at birth. Appetite may be normal or capricious. In some cases it is ravenous. Shortly after birth it is noted that a usual feeding routine provokes *vomiting*. The vomiting comes on soon after the meal. It commonly follows every feeding and it is evident that feeding produces it. In no ailment are cause and effect more definitely emphasized. At first, vomiting may be sudden and projectile, the contents of the stomach sometimes being thrown several feet. At this time vomitus consists of the food swallowed but a few minutes previously. Later, where obstruction is pronounced and when gastric dilatation and muscular atony have become marked, vomitus is not projectile and retained food (tough milk curds, etc.) is vomited or washed from the stomach. The vomitus is commonly bile-free, has a sour odor, may be hyperacid and contain an excess of mucus.

Pain.—Until gastric atony has occurred, the infant manifests distress before and during emesis by cries and grimaces. Pain is produced by powerful hyperactive gastric peristalsis. When the stomach is empty, the child is comparatively comfortable, although it may be hungry. When gastric atony and dilatation have taken place, starvation and its resultant weakness render the child listless, drowsy and apathetic.

Constipation is pronounced. The stools are of small volume, dark in color and nearly or entirely food-free.

Urine output is diminished. The urine is of high color and deeply stains the diapers.

Signs.—*Weight loss* is commonly progressive and pronounced. *Emaciation* may become startling. The skin is pale, dusky, dry and inelastic; the hair lusterless and brittle. The mucosæ are pale, dry, scaly and often fissured. Panniculus disappears early. The muscles become small, soft and flabby. Lack of body fluids is seen in all tissues provided rectal alimentation has not been instituted.

Abdominal Tumor.—When the infant is stripped, *visible peristaltic waves* may be seen to pass rhythmically across the epigastrium from left to right. During, or shortly following feeding, these waves are pronounced, particularly in the early stages of the affection when gastric musculature is still capable of powerful contractions. As the waves approach the right upper abdominal quadrant, a definite tumor-like bulging may be seen. This is best observed when the belly is viewed with the eye at its level. *Palpation* frequently reveals a small, firm, movable tumor above the navel and toward the right rib margin. This tumor is best felt as the peristaltic waves pile up toward the pylorus. The pylorus is at that time rotated downward and forward. Inflation of the empty stomach by means of a double-bulb, Davidson syringe, through a small-calibered stomach-tube, occasionally permits the palpation of a tumor that lies up under the right ribs or the liver. Examination of the belly after the patient has lain in a tub of water at 100° to 105° F. for ten or fifteen minutes further facilitates the palpation of the tumor. This maneuver also aids in demonstrating the movability of the pyloric nodule. At such time the tumor may be grasped readily between the fingers.

Carmin Test.—Two grains of carmin may be suspended in a half ounce of hot, sweetened water and given the infant by mouth. If no red coloration appears in the stools, pyloric obstruction is complete. In *cases of partial stenosis,* the stools may be but faintly colored or the colored stool may not be seen for as long as thirty-six to seventy-two hours.

Roentgen Examination.—When the stomach is filled with an opaque mixture (barium, bismuth) fluoroscopic examination discloses a dilated stomach, hyperactive early in the course of the ailment, but atonic in the late stages; opaque-meal residue for longer than six hours; well defined, ring-like, filling defect at the pylorus; imperfect or absent visualization of the duodenal bulb and poorly filled or empty small or large gut. The stomach can be shown to be freely movable. Copious regurgitation or spasmodic squirting of the opaque-meal into the esophagus may be striking. Roentgenograms furnish a convenient graphic record of the major fluoroscopic observations.

Diagnosis.—When a newly born infant constantly vomits its food soon after eating, hypertrophic stenosis of the pyloric must be considered to exist until definitely proved to be absent. If, as Scudder emphasizes, the obstructive vomiting is associated with palpable, epigastric tumor, visable gastric peristalsis, dilatation of the stomach, progressive weight loss, emaciation, constipation, meconium-like stools, deficient urine output, absent carmin coloration or barium or

bismuth crystals in the stools and the roentgen proof of stenosis at the pylorus, diagnosis amounts to almost a certainty.

Pyloric spasm may occur in infants who have been improperly fed. It rarely complicates true hypertrophic pyloric stenosis. Pyloric spasm usually comes on weeks after birth, whereas stenosis in infants manifests itself from birth. In pyloric spasm the picture is a variable one: feeding causes vomiting intermittently; the vomitus is rarely constantly projectile; not all the meal eaten is vomited; the stools contain considerable partly digested food; carmin and bismuth crystals are readily detected in the feces; palpable epigastric tumor is seldom definite and constant; visible peristalsis is poorly determined; the roentgen examination shows a normal pyloric outline and the pyloric lumen is patent; all symptoms and signs may cease following the administration of belladonna, bromides or proper diet. The infant may, but rarely does, die of starvation.

Intussusception, volvulus, appendicitis, infectious ailments, cerebrospinal affections, intestinal parasites, nephritis or *indigestion due to improper feeding* may cause vomiting in early life. The history of these ailments differs markedly from that of congenital, pyloric stenosis. Such affections rarely appear in the first few days of life. Their course, clinically, the character of the vomitus, the appearance of the stools and the roentgen observations usually serve readily to differentiate them from hypertrophic stenosis. Cases occasionally prove puzzling, but careful anamneses, physical examinations, and clinical observation over a few days generally establish their diagnoses.

Prognosis.—Congenital hypertrophic stenosis of the pylorus rapidly causes death unless the obstruction be removed or gastro-enterostomy is performed.

Congenital Enlargment of the Stomach.—Congenital enlargment of the stomach is very rare. It represents a relative overdevelopment of the endodermal *anlage*, probably as a consequence of an anomaly in innervation and circulation. Occasionally, cicatricial adhesions forming, or pressure, as result of unusual position of the fetus in intrauterine life, would appear to cause dilatation proximal to that portion of the gastric lumen stenosed. Soon after birth, the initiation of feeding produces dilatation of the weakened stomach walls.

Diagnosis.—It is uncommon for such to be made previous to laparotomy or autopsy. The symptoms are those of obstruction: vomiting, constipation, lessened urine output, possibly visible abdominal peristalsis and emaciation. The roentgen examination demonstrates the abnormally large stomach.

Prognosis.—Death ensues from starvation and exhaustion, unless surgical procedures or, in rare cases, careful dietetic regimen, are possible.

Congenital Faulty Position of the Stomach.—*Situs Inversus.*—The position of all the abdominal viscera may be reversed. The fundus of the stomach may lie wholly or partially to the right of the midline, the pylorus being directed to the left (Fig. 252). A full

discussion of the mechanism of the anomaly and its consequences is found in Arneill's monograph.[1]

Diagnosis.—The patient generally manifests no clinical symptoms from the reversed placement of the stomach alone. The condition is commonly discovered during routine physical examination or the study of a dyspepsia. Roentgenographic investigation conclusively proves

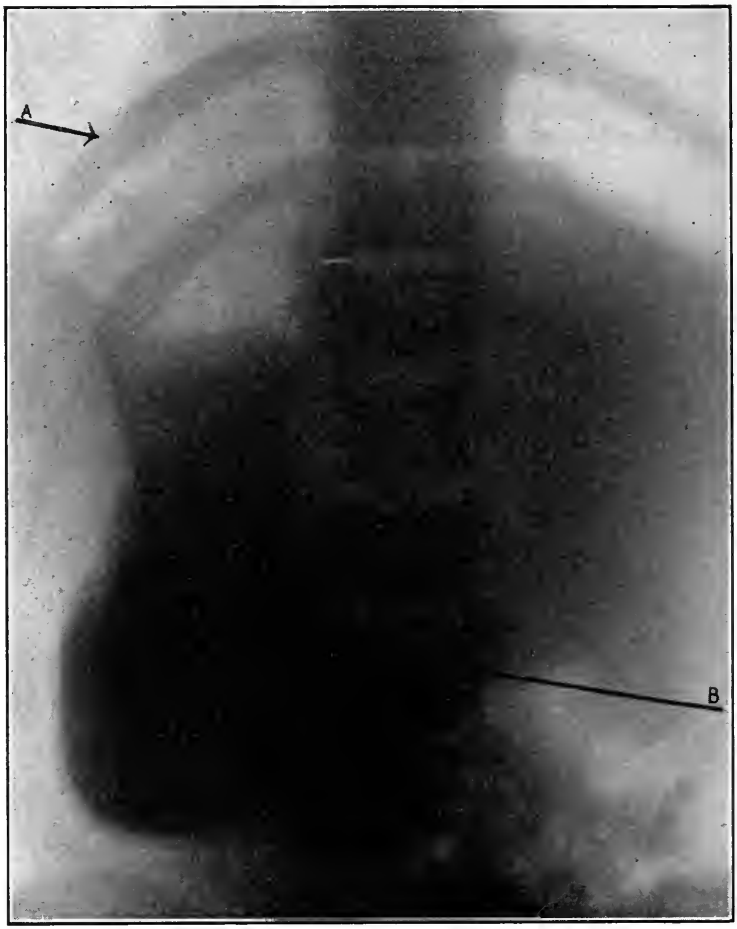


FIG. 252.—Transposition of viscera (*Situs inversus*) in a girl, aged twelve years, showing heart apex at *right* nipple and pylorus of stomach emptying to *left*. *A*, heart apex at *right* nipple; *B*, pylorus emptying to *left*. (Original observation by author.)

the anomalous position of the viscus. If such study be not possible, in a suspected instance, inflation of the stomach with air through a stomach tube, permits of ocular proof that the organ is unusually located. Further evidence may be found in the location of the second esophageal

[1] Vaughan's Festschrift, Ann Arbor, 1902.

swallowing murmur to the *right* of the vertebral column and escape of gas or fluid from a pylorus located to the *left* of the midabdominal line.

Prognosis.—Situs inversus is not of itself incompatible with perfect health. Associated lesions (ulcer, cancer, stenoses, etc.) determine the outcome.

Congenital Elevation of the Diaphragm or "Eventration," commonly results in the stomach occupying a wholly or partially "intrathoracic" position. The condition is important, clinically, chiefly on account of the readiness with which the anomaly is confused with congenital or acquired hernia of the stomach through an imperfectly developed or an accidentally injured diaphragm. The condition has been carefully described by Glaser, Leichtenstein and by Sailer and Rhein. About 25 authentic cases are recorded in the literature.

Etiology and Morbid Anatomy.—Meckel mentions an instance in a female fetus. Thoma described the findings at autopsy in a man of seventy-five. It is thus apparent that *age* is but of relative significance in grouping the cases. Males appear to be about twice as frequently affected as are females. In two-thirds of the patients diagnosis was not suspected during life. Heredity does not appear to have definite significance. Other congenital anomalies may coexist: *viz.*, lack of proper development of the left lung, atypically shaped pancreas, deficiency in development of the muscles of the left side of the body, particularly the diaphragm, etc.

Anatomic Variations.—The left half of the diaphragm is commonly involved. It is abnormally high-placed, congenitally. Its dome may reach to the level of the third rib. *Its continuity is unbroken.* There is frequently an associated displacement of the heart toward the right and a hypoplasia of the left lung. The muscle layers of the left diaphragm are sometimes thin and their bundle-formation fragmented. The stomach and adjacent viscera may lie high in the thorax. They do not, however, protrude *through* the diaphragm into the thoracic cavity. The respiratory excursion of the left half of the diaphragm may be limited.

Clinical Symptoms and Signs.—Nothing abnormal may be noted during life. Affections of the lungs, heart or abdominal viscera commonly lead to examinations at which unusual anatomic placements of organs are noted. Operative procedures may be performed on the supposition that the high position of hollow viscera, the stomach or the colon, indicate hernia through the left half of the diaphragm.

The symptoms of an associated gastric lesion (ulcer, cancer, etc.) may be anomalously referred to the left thoracic region. Gaseous distention of the stomach with pressure upon the heart, dyspnea, thoracic gurgling or pain, dysphagia, constipation and occasionally, obstinate vomiting, have been described.

Signs of the affection are not lacking in well marked instances. Percussion of the upper part of the left lung may be normal, but below the third or the fourth rib tympany may be striking. The heart is pushed to the right. Litten's sign is absent or limited on the left side.

The area of thoracic tympany may be displaced downward by deep inspiration. Auscultation over the left lower thorax reveals splashing and gurgling sounds, particularly if the patient is shaken or he swallows fluid during the examination. Amphoric voice tone and the "coin sound" are absent over the tympanitic thoracic zone. If the stomach be filled with solid food or fluid the area of thoracic tympany gives place to one of dulness. Splenic dulness may not be outlined. When a stomach-tube is passed it commonly enters the viscus at less than 30 cm. from the teeth. Inflation of the stomach through a tube may cause left thoracic bulging, dyspnea, added cardiac displacement, increased zone of thoracic tympany and auscultatory phenomena in the left thorax.

When the patient is fluoroscoped, normal diaphragm contours may be seen on both sides. On the left side, the diaphragm is seen to occupy an abnormally high position. During respiration its movements may be synchronous with those on the right side—but its excursions are usually less rapid and complete. Below the high left diaphragm, the gas bubble in the stomach, gas in the splenic loop of the colon or the shadow of a high-lying spleen may be noted. When an opaque mixture of barium or bismuth is swallowed, displacement of the esophagus, anomalously located cardiac orifice and a "thoracic" lying stomach are demonstrated. Roentgenograms furnish interesting graphic records of the unusual locations of the abdominal and thoracic organs.

Differential Diagnosis.—Eventration of the diaphragm with congenitally high-placed stomach is rare. It is most important to differentiate the condition from congenital or acquired diaphragmatic hernia. The latter affection is potentially if not actually surgical; eventration is surgical only accordingly as anomalously placed viscera become diseased.

Diaphragmatic Hernia. — **Congenital.** — In such instance the diaphragm fails to properly develop, usually on one side. Occasionally the lack of development is symmetric and, as a consequence, the normal openings in the diaphragm are of greater size than when development has been complete. Usually, when there is improper formation of the diaphragm, the overlying peritoneal layers are absent. It thus follows that congenital hernias of abdominal viscera through the diaphragm are not true hernias, because the viscera are not enclosed in the peritoneal sac.

Congenital hernia of the stomach through the diaphragm is rare, but a few authentic cases are on record. An instance has recently been described by Seymour Baasch. In this case, there were no gastric symptoms or any evidences of disability until the patient reached adult life. At that time the symptoms were those of chronic obstruction. The obstruction was clinically similar to that caused by ulcer of the stomach producing hour-glass. The gastric analyses pointed toward peptic ulcer and the *x*-ray examination revealed an atypical hour-glass stomach, the pyloric end of which seemed displaced upward into the

right lower thoracic cavity. Exploratory laparotomy disclosed the true nature of the affection. The patient died within thirty-six hours after an attempt to relieve the hernia.

Acquired Hernia of the Stomach through the Diaghragm.—While uncommon, it is of sufficient frequency at large surgical clinics to be of considerable interest. Instances of the affection have been reported and described by Beckman, Giffin and by Sailer and Rhein. The lesion is usually on the left side, but occasionally the stomach has been found in the right side of the thorax. About 650 cases of diaphragmatic hernia have been reported but in relatively few of them has the stomach been herniated.

The clinical history usually points to severe trauma initiating the hernia. Such traumata are commonly a severe blow to the upper abdomen or lower thorax, a sudden twisting, a stab wound, or a doubling-up or crushing injury. According to Giffin, the acute manifestations of the anomaly are sudden, severe, abdominal or thoracic pain with or without hematemesis. There is usually pronounced dyspnea and symptoms of intestinal obstruction soon follow.

If the causative trauma does not immediately bring about a fatal issue, the condition of hernia of the stomach through the diaphragm may become chronic. In such event the symptomatology may closely resemble that of eventration of the diaphragm. Sometimes there are *no symptoms* but the hernia of the stomach into the thoracic cage may be accidentally discovered in the course of routine examination or during surgical procedures. The majority of cases, however, exhibit attacks of abdominal pain, vomiting, dyspepsia with or without hematemesis and occasionally, periodic dyspnea.

Pneumothorax, hydropneumothorax, tuberculous cavity formation in the lung, subdiaphragmatic pneumothorax, pyloric stenosis, or disease of the gall-bladder may at times simulate diaphragmatic hernia. These conditions may be difficult to differentiate unless emphasis be placed upon careful anamnesis, physical examination and roentgen study.

Physical Signs.—In diaphragmatic hernia, Litten's sign may be greatly diminished or absent on the affected side—usually the left. On percussion of the left thorax, tympanitic note may be demonstrated as high as the fourth rib when the stomach is empty, but when the stomach is filled there may be an anomalous area of dulness ascending high into the left thorax. If the stomach is inflated by means of a Seidlitz powder, thoracic tympany and hissing, splashing or gurgling sounds may be heard practically all over the left thorax. The signs may differ when the patient's position is changed. Dyspnea may be pronounced, particularly in cases of acute herniation.

If a stomach tube be passed, gastric content may be obtained when the tube is at but a short distance (15 to 20 cm.) from the teeth.

X-ray Evidences of Gastric Herniation through the Diaphragm.—Fluoroscopic examination may reveal a stomach gas-bubble lying *above* the line of shadow cast by the diaphragm. This gas-bubble may move up

and down during respiratory movement and may change in size at different examinations. The diaphragm contour may be definitely seen to be broken. The diaphragm may apparently lie higher than normally and the movements during respiration may be limited. A paradoxical expiratory displacement of the diaphragm has been described. In such event, during deep inspiration, the unaffected diaphragm descends normally while the diaphragm on the affected side ascends. During forced expiration, the unaffected diaphragm ascends normally, while the diaphragm on the affected side descends. The rate of excursion of the diaphragm on the two sides may differ.

When the stomach is filled with an opaque medium, all or part of the stomach-shadow may lie above the shadow cast by the diaphragm on the affected side. There is usually deformity in the stomach contour: this may frequently amount to actual hour-glass constriction.

A greatly dilated stomach, which has herniated through the left diaphragm, may displace the heart to the right and may cause partial collapse of the lower left lung. Usually, however, cardiac displacement is not great and at the fluoroscopic examination, normal lung tissue may be observed through the gas-bubble distending the upper part of the stomach-shadow. When the stomach is not entirely filled by the opaque meal, at fluoroscopic examination, palpation of the stomach may enable one to demonstrate fluctuation waves in the stomach lying at a level higher than the diaphragm-shadow on the affected side.

When, in addition to the hernia of the stomach through the diaphragm, there is also hernia of the large or small gut or the spleen, then the fluoroscopic signs are complicated. Inflation of the stomach or the colon alternately with air may reveal definite differences in the size and shape of the gas-bubbles lying in the thoracic cavity, above the diaphragm shadow on the affected side. In such event, the physical signs upon auscultation and percussion vary greatly.

It is important to recognize hernia of the stomach through the diaphragm because this condition is amenable to surgical treatment. As has been emphasized above, it is particularly desirable to differentiate the affection from congenitally high-lying diaphragm on one side (so-called "eventration"), which is never a surgical condition unless it be that the highly placed diaphragm is also the site of hernia.

GASTROPTOSIS.

Definition.—An anomaly associated with an abnormally low position of the stomach, particularly of the pyloric third of the viscus. Gastroptosis is doubtless most commonly *congenital*, but, as a consequence of incorrect dress, posture, habits or of infectious or constitutional ailments, unusually low position of the stomach may be *acquired*.

Congenitally low stomachs may functionate normally throughout life. Discovery of the anomaly may be accidental. Intercurrent disease, may, however, produce disability in a low-lying stomach, whereas such intercurrent disease might cause little or no incon-

venience in a stomach in so-called normal position. When gastroptosis has resulted from faulty modes of living or has been brought about by a systemic or constitutional disease, then dyspepsia not rarely becomes evident.

The position of the normal stomach is subject to such wide variations in individuals who are apparently healthy that it is difficult to state just what constitutes "gastroptosis." While it is the popular rule to consider all stomachs whose pyloric thirds lie below the level of the iliac crests as being ptosed, yet the routine examination of large groups of individuals demonstrates that such positions of stomachs are by no means unusual or inconvenient. It would seem best to limit the term gastroptosis to those instances in which the ptosis is a part of a generally low-lying, gastro-intestinal tract and in which definite signs and symptoms directly referable to such unusual position can be ascribed. In general, when the major portion of the stomach and intestines lies in the pelvis, inconveniences amounting to actual malfunction frequently arise. It is surprising, however, in how many such cases of markedly low-lying viscera there occurs no anomaly in secretion, motility or assimilation.

Gastroptosis is more common in females than in males. In a recent study of the position of the stomach in 600 males and females (300 each), gastroptosis was noted in but 36 males while it was present in 162 females. These figures would seem to indicate that the low-lying stomach is almost a normal event in females. While modes of dress, child bearing, lack of exercise and frequently insufficient nourishment may be factors in producing low gastric position in females, yet such explanation is by no means sufficiently comprehensive.

Clinical Symptoms and Signs. — As briefly hinted above, marked gastroptosis may occur without manifesting itself in any way, clinically. While low position of the stomach may be proved, this low position is not of itself indicative of any upset. In some groups of cases in which stomach ptosis exists, chronic dyspepsia is manifested. Patients frequently attribute the onset of this dyspepsia to a "nervous breakdown," a recent illness, childbirth, an injury or prolonged mental or physical stress.

Symptomatically, there are not infrequently sensations of discomfort in the region of the stomach. These rarely amount to actual, clean-cut pain. The distress is most commonly pronounced shortly after food ingestion. The discomfort is variously described as "dragging" or "fulness" or "pressure" or a vague soreness. Colicky pains are unusual. When the stomach is empty, abdominal discomfort is generally slight, although individuals of the nervous type not rarely are annoyed by burning or aching sensations.

Nausea and vomiting are quite regularly experienced in marked instances of the affection. Vomiting may come on shortly after food ingestion, but morning vomiting with nausea may be annoying. In this group of cases, the vomitus may contain retained food, strings or gobs of mucus and bile, more or less altered. Morning vomiting is

sometimes copious and associated with troublesome "gagging." In young individuals, eructations, pyrosis or water-brash may be particularly distressing.

Appetite is usually poor or capricious. Malnutrition may be of particularly severe degree—so marked as to lead to the clinical suspicion of malignancy especially in people at the so-called "cancer age." This malnutrition can quite commonly be attributed to insufficient ingestion of food and liquids. Weakness and weight-loss are sometimes striking. Patients may be actually bed-ridden. Constipation is the rule. There may be diminution in urine output. The urine is often high-colored and rich in uric acid, phosphates and substances of the indican group.

Signs of Gastroptosis.—Physically, many patients with low-lying stomachs are of slender build. Their bones are apt to be small and their posture incorrect. When such patients stand erect, flat foot may be noted, there may be a drooping of the shoulders, flattening out of the normal lumbar curve of the spine, a narrowing of the epigastric angle, and not infrequently a definite, transverse crease in the abdominal muscles at the level of the navel. While the epigastrium may be flat, it is not uncommon to observe a globular bulging of the abdomen below the navel. This bulging may be very noticeable. In some instances, owing to the thinness of the abdominal muscles, practically the entire stomach, together with portions of the large and small intestines, may be well visualized. Occasionally, peristaltic waves are seen in both stomach and intestines. The patients appear starved, as a rule, the skin and hair are apt to be dry, the panniculus is thin and the muscles soft and flabby. This muscular weakness is apt to be most pronounced in the anterior abdominal group.

Abdominal palpation generally demonstrates a lessening of the muscle tone, a dilated, atonic and frequently splashy stomach, areas of distress over the stomach or bowel and not infrequently, points of tenderness over the gall-bladder or appendix regions.

Test meals returns show eight hour food stagnation as constant in about 3 per cent. of patients. In approximately 11 per cent. intermittent, eight hour retention can be demonstrated. Bile staining of gastric extracts is not uncommon where an atonic stomach with relaxed pylorus exists. Sometimes excessive amounts of mucus are present in the wash water. The gastric acidity varies greatly not only in groups of cases, but, frequently, in the same individual examined at different times. In young patients, increases in the free hydrochloric acid are apt to be recorded, but where patients are past midlife, free hydrochloric acid may be low or absent. When the stomach is inflated with air through a stomach-tube, by means of a double-bulbed Davidson syringe, its position together with evidences of its increase in size, and not uncommonly its lack of muscle tone, can be readily determined.

X-ray Examination.—There is no clinical procedure that has created such unnecessary apprehension among both patients and physicians as has the ocular proof of the so-called "low-lying stomach." At the same

time, to physicians of judicious mind and not of faddist mentality, the radiological studies have proved particularly instructive in teaching how wide may be the variations in the positions of stomachs and yet in such stomachs no malfunction exist. Gastroptosis has, however, become firmly established as a clinical entity in the minds of the laity mainly on account of roentgen examinations and the injudicious comments upon such by physicians who had certain types of treatment for this ailment. Many ingenious operations have been devised for the purpose of lifting and anchoring the so-called ptosed stomach to a position which according to physiology primers seemed correct, and many forms of medical regimen have been instituted with a similar object. With few exceptions the benefits of such treatments have been more apparent to the physician doing the treating, than to his subject.

Fluoroscopic Examination.—Six-hour residue of the opaque meal may be a variable factor. In instances where there is marked gastric atony, some degree of six-hour retention may be a constant finding.

Ptosed stomachs are generally of the so-called "fish-hook" shape. The lumen is apt to be narrowed but not necessarily so. Both greater and lesser curvatures are commonly below the level of the navel or the iliac crests. The gastric contour is usually normal. In some instances of gastroptosis peristaltic waves are absent or poorly developed. Many examples of the affection, however, exhibit vigorous peristalsis. The stomach can be freely moved up and down and from side to side, by palpatory massage. Sometimes it can be shown that the pylorus is permanently relaxed, but this should be always corroborated by repeated examinations, inasmuch as the tone of the pylorus may vary greatly in the same individual at different times. Other instances occur in which not only the gastric tone generally but the tone of the pyloric sphincter is greatly increased. In such affection, the pyloric spasm may be so pronounced as to result in intermittent gastric retention and difficulty in filling out the duodenum during fluoroscopic examination. The duodenum is commonly well visualized and sometimes is greatly dilated, particularly if part of that gut is involved in pericholecystitic adhesions. It may then empty slowly. These factors are, however, variable.

Rarely during the fluoroscopic examination can adhesions, fibrous bands or abnormal position of abdominal viscera other than the stomach be demonstrated to be the direct cause of the ptosis.

X-ray plates are of comparatively little value in the clinical estimation of the degree of gastric function existing in the low-lying stomach. Certainly, a single plate never should furnish evidence upon which therapeutic procedures are to be based or to demonstrate the effects of such procedures.

Plates made in series generally corroborate fluoroscopic examination but their value is not so great as is that procedure. Such plates are, however, useful in certain instances, in demonstrating extra-gastric conditions that have primarily instituted the systemic disturbance of which the gastroptosis is a part.

GASTRIC HEMORRHAGE. (GASTRORRHAGIA.)

Bleeding from the stomach may be acute and copious or chronic and in small quantity. Both types of hemorrhage may be continuous or intermittent, with complete cessation in the intervals. A combination of the forms is possible.

Sudden, copious gastric hemorrhage commonly leads to bloody vomit (*hematemesis*) and to blood-stained stools (*melena*). However, even extensive gastrorrhagia may be unaccompanied by hematemesis, but manifested by melena alone. Chronic seepage of small quantities of blood is, of itself, rarely productive of hematemesis. While this form of gastrorrhagia may give rise to obvious melena, quite commonly the presence of blood pigment in the stools can be demonstrated only by chemic, microscopic or spectroscopic tests (so-called "altered" or "occult" hemorrhage).

Etiology.—Sudden, copious bleeding from the stomach is dependent upon accident or is a complication of a previous local, general or constitutional ailment. It may be so acute and extensive as to prove rapidly fatal. Moderate or abundant hemorrhages may occur at frequent or infrequent intervals. There is often a peculiar tendency to recurrence. The quantity of blood lost at each attack may vary greatly in a given case.

Seepage or "occult" bleeding from the stomach is generally associated with primary progressive pathological changes in the gastric mucosa or is a secondary, local manifestation of a systemic or constitutional fault.

In the different types of gastrorrhagia, the histopathological condition of the stomach mucosa varies from simple, capillary congestion, with rupture (or even cell diapedesis) of minute capillary networks, locally or generally, to extensive loss of surface epithelium with destruction of the layers of the stomach wall and the erosion of large bloodvessels. Either process may begin intramurally, in which event the mucosa first suffers, or extramurally, when the bloodvessels are primarily affected. There is a type of gastrorrhagia which periodically occurs in females, in definite relationship to the menstrual cycle, where copious hematemesis may be associated with no gross gastric pathology. In the hematemesis accompanying certain anemias, infectious ailments, acute and chronic systemic toxic states or following operations upon intra-abdominal viscera other than the stomach or the duodenum, there may likewise be no grossly apparent lesion in the stomach mucosa.

Gastrorrhagia is associated with hematemesis or melena or both as follows:

(*a*) In primary gastric disease: acute or chronic gastritis, simple or phlegmonous, acute gastric erosion, acute or chronic benign ulcer, *ulcus carcinomatosum*, carcinoma, sarcoma, syphiloma, tuberculoma, polyposis, ulcerated gastric cirrhosis, varicosities or aneurysm of intrinsic gastric arteries or intramural parasite (echinococcus, nematodes.)

(*b*) In conjunction with chronic disease of the heart or bloodvessels.

(*c*) Complicating chronic disease of the liver, gall-bladder or ducts (cirrhosis, neoplasm, portal thrombosis, Banti's disease, cholelithiasis, cholecystitis.)

(*d*) Disease of the spleen (chronic splenitis, leukemia, Gaucher spleen).

(*e*) Malfunction of the pancreas (acute and chronic pancreatitis).

(*f*) Toxemias associated with ailments of the kidney, central nervous system, thyroid gland, adrenal, hemolymph nodes.

(*g*) Bacteremias or protozoemias: typhoid fever, smallpox, measles, malaria, yellow fever, cholera.

(*h*) Chemic poisons: phosphorus, arsenic, hydrocyanic acid, split-proteins or their products, burns.

(*i*) Local injury—(1) falls, foreign bodies, blows, crushing injuries or stab wounds (2) poisons introduced by mouth.

(*j*) Disordered blood states: hemophilia, purpura, chronic anemia—"secondary" or "pernicious"—acute or chronic cholemia.

(*k*) In connection with certain vague neuropathic states: hysteria, angioneurotic edema, tabetic crises, epilepsy, progressive paralysis.

(*l*) Associated with physiological cycles of females: the catamenia and climacteric.

(*m*) Following operations upon organs other than the stomach, particularly when such operations are intra-peritoneal.

(*n*) Blood may enter the stomach from a diseased lung, esophagus, adjacent viscus, (duodenum, jejunum or colon, by fistula) or a nearby, great vessel.

Morbid Anatomy in Gastrorrhagia.—Gross or microscopic alterations in the stomach wall bear but an irregular relation to the quantity of blood present in the viscus, vomited or passed by the bowel. Abundant, even fatal, hemorrhage may occur and yet no visible source of such can be demonstrated in the mucosa. This is apt to be so where profuse bleeding is associated with infectious disease, cirrhosis of the liver, surgical operations not on the stomach, hysteria, burns on the surface of the body, blood dyscrasias or traumata to the abdominal wall. Commonly, however, gastrorrhagia is found in connection with some type of peptic ulcer or carcinoma. In such ailments, fissures, granulating ulcer edges or necrotic tumor areas can be noted in definite relationship to bloodvessels.

After severe hemorrhage the stomach mucosa appears pale, yellowish-pink, often with scattered areas of reddish-brown mottling in the mucosa and the submucosa. Some grade of general edema is present. The mucosa dries rapidly when exposed to the air and then has a smooth, shiny appearance. The rugæ are indefinite and the muscle wall is flabby and inelastic. When peptic ulcers bleed profusely and intermittently, local destruction of the stomach wall often associated with peritoneal adhesions, is common. Of 185 operated gastric ulcers in our series where gross hemorrhage has been recorded in 78 (42 per cent.) some grade of protected perforation of the stomach wall was noted.

In acute, profusely bleeding ulcers, tissue necrosis may take place so rapidly that peritoneal protection is impossible and perforation occurs, even before hematemesis or melena appear. The symptoms and signs of the perforation may mask those of severe hemorrhage. At laparotomy, the stomach is seen to be filled with clotted blood and food, while between the coils of the intestines or in the peritoneal sacs may be found blood-clots, serous fluid, pus or food.

Seepage of blood into the stomach is most frequently noted in connection with granulating ulcer edges, ulcerating, necrosing cancer, in achylias (primary as result of chronic atrophy of gastric mucosa, or secondary to idiopathic anemias or blood disorders) or in extragastric malignancy. With exception of the achylias, the mucosa is generally edematous, congested and bleeds readily on handling. In the achylias, the mucosa is often thin, pale and smooth. If it is scraped with a knife, a pale, reddish-brown fluid can be collected, which chemically or physically, can be proved to contain blood pigment.

Signs and Symptoms. — (*a*) *Hematemesis.* — Sudden vomiting of large quantities of blood may occur without noticeable premonitory symptoms or previous evidences of disease. The vomited blood may be bright-red and fluid. It is commonly mixed with undigested food and mucus. Clots may be present. They usually occur toward the end of emesis or when the blood has lain in the stomach for a time before being vomited. In general, the higher the gastric acidity the smaller and fewer the clots. When the acidity has previously been low or where hemorrhage has neutralized free hydrochloric acid, coagula form relatively quickly. The *quantity* of blood vomited varies greatly in different patients or in the same individual on different occasions. The hematemesis may not represent the extent of the gastric hemorrhage: a cupful may be vomited and yet the stomach remain filled with free or partly clotted blood which is later vomited, passed by the bowel or washed from the stomach. Such condition often leads to a false sense of security. Clots in the gastric lumen may temporarily stop hemorrhage or may mask a gradual, but persistent, bleeding which, subsequently, as a result of error in diagnosis or treatment, may prove fatal. Enormous hematemesis sometimes occurs. In one of our cases, nearly eight quarts of free and clotted blood were vomited.

Slow seepage of blood rarely precipitates hematemesis. In such instances vomiting may result from other causes. When this happens, the vomitus is colored reddish-tan, brown or even black. In advanced gastric carcinoma or in pyloric obstruction caused by eroded ulcer, such vomitus is not uncommon.

(*b*) *Melena.*—Practically all instances of blood seepage from the stomach and nearly all cases of profuse gastrorrhagia are accompanied by stools more or less colored with blood or blood pigment. Where rapid loss of blood occurs, the stools may be bright red and mixed with clots. Commonly, however, the stools are dark brown or slate black. Not infrequently abundant hemorrhage from the stomach may be unaccompanied by hematemesis, but melena may be observed either

within a few hours of other clinical evidences of internal bleeding or after an interval of a day or more. Unless stools are carefully scrutinized, such hemorrhage may be overlooked, and serious consequences follow.

Where seepage of blood occurs, the stools may be but slightly altered in gross appearance and unless search for blood pigment be made in the laboratory, the existence of an "occult" gastrorrhagia may remain unsuspected.

Chemical Tests for "Occult" Hemorrhage.—In retention stomach contents, positive occult blood tests are not rarely caused by the food contained therein. In such an instance, it can readily be seen that the test has no clinical value, viz., the positive tests may be due entirely to retained food in the absence of a gastric lesion or it may be due both to a bleeding gastric lesion and to the food admixture. Similar cautions apply with respect to making occult blood tests upon stools. It is quite necessary, when performing chemical tests for blood pigment in feces, to be sure that errors are not due to foodstuffs, medicines and other alimentary tract residues.

A reliable procedure is to place the patient upon a diet free from meat, meat extracts and chlorophylaceous vegetables for at least two days. During this time foods or medicines containing iron compounds, should be interdicted. On the day upon which the feces are to be collected, the patient should receive nothing but simple cereals, gruels, or milk preparations. The second stool passed, preferably following brisk catharsis by salines, should furnish the specimen to be tested for blood. The technic for such test has already been given (*vide supra*, page 591).

Of course it should be understood that the positive tests for occult blood in feces merely indicate that there is a bleeding point somewhere between the lips and the external anal ring. It is the business of the physician to locate this bleeding point. To do this, there must be careful scrutiny of the clinical history and a careful physical examination must be made. Stools passed during the menstrual period are not infrequently admixed with blood. This should be particularly appreciated in the examination of stools from females.

(*c*) *Systemic Evidences of Bleeding.*—If the hemorrhage has been of small quantity, there may be but slight physical evidences of such. Where a large amount of blood has been lost in a short time, pallor, cold, clammy skin, sighing respiration, with or without rapid pulse, low blood-pressure and dilated heart are usually evident. Fainting frequently occurs. In some instances there is delirium. The temperature is usually subnormal at first, but in serious cases, there may be an abruptly developing hyperpyrexia, particularly shortly before death.

Gastric hemorrhage is not infrequently accompanied by severe abdominal pain. Unless the hemorrhage has been sudden and severe, the discomfort produced by the pain may mask the clinical evidences of threatened shock and collapse. Patients not uncommonly suffer extensive hemorrhage without hematemesis. The blood passes into the bowel and remains unrecognized. In these patients shock, collapse and

death may occur without the underlying causes being discovered until laparotomy or autopsy is performed. In a chronic dyspeptic or in the course of an acute attack of indigestion, the appearances of anemia and shock should always be taken to signify hemorrhage until such signs are proved to be due to other causes.

Where hemorrhage complicates the actual perforation of a gastric lesion—ulcer or cancer—the development of perigastric abscess, general peritonitis or fistula may cloud the diagnosis.

Prognosis.—About 3 per cent. of instances of gastrorrhagia are acutely fatal. Often repeated hemorrhages, occurring within a brief interval raise the total early mortality to about 8 per cent. Sometimes the hemorrhage itself is not fatal, but death is caused as a consequence of the lighting up of infection, by perforation with peritonitis or by heart or kidney failure due to sudden lowering of systemic resistance.

GASTRIC ULCER.

Definition.—A form of gastric malfunction associated with a local loss, first, of tissues making up the mucous membrane, and later; of the deeper structures of the stomach wall. The defect is usually single but multiple lesions are by no means rare. The ailment has a peculiar tendency to chronicity with respect both to the local histological change and the duration of its continuance.

Etiology.—Recent and experimental clinical studies point to a wide variety of systemic, constitutional or gastric upsets which may be associated with peptic ulcer. There is considerable evidence indicating that the ailment is not a gastric disease *sui generis* but that most commonly it is, gastrically, the local manifestation of a systemic disorder.

Relative Frequency.—Until modern surgery returned definite information respecting peptic ulcers, it was commonly held that gastric ulcer is of more frequent occurrence than is duodenal. In a recent study made by the writer of 1842 operatively demonstrated instances of peptic ulcer, duodenal ulcer occurred approximately two and one-half times as frequently as did gastric.

Age.—The greatest number of cases occurs between thirty and sixty years; 27.2 per cent. occurred between thirty and forty years of age.

Sex.—Males are affected nearly three times as frequently as are females. In males, the greatest number of cases occurs at nearly a decade later than in females.

Nationality.—In Europe gastric ulcer is most common among the Scandinavians. In America their descendants likewise contribute a large proportion to the ulcer class. In Southern Europe and in warm climates generally, the affection is comparatively infrequent. Germany, Austria, England and northern France exhibit a frequency of incidence quite comparable to that found in the United States and Canada.

No occupation is apparently immune from or causative of the disease. It is perhaps noteworthy that nearly 32 per cent. of the cases studied by the writer were in individuals from rural communities.

Habits.—In 26 per cent. of instances, spirits had been used to excess, while many of the histories indicated the use of tobacco; in but 3 per cent. had its excessive use been indulged in. Dietetic errors were commonly recorded, but it was not observed that this feature had particular etiologic significance.

Previous Infectious Diseases.—In nearly 60 per cent. of the cases, there occurs a history of frequently recurring acute infectious ailments (tonsillitis, la grippe, sinus disease, scarlet fever, rheumatism, malaria, typhoid fever, etc.) or the patient dates the beginning of his disorder to an acute exanthematous disease. Seasonal recurrences of discomfort were noted in nearly 40 per cent., Spring and Fall being favorites. When it is recalled that in these seasons acute infectious diseases are very common, the relationship of microörganisms in respect to the production of peptic ulcer or with regard to reëstablishing activity in healed foci, seems worthy of more than casual note. The experimental researches of Rosenow would apparently substantiate such association.

Morbid Anatomy.—From whatever methods gastric ulcers are produced, experimentally or from constitutional upsets, the resultant lesions are essentially similar. There occur local loss of surface epithelium, necrosis, inflammatory edema, hemorrhage and glandular destruction. If the underlying causes of the affection persist, then such, coupled with the digestive action of the gastric juice, bacterial infection, food traumatism and more or less altered gastric peristalsis, may permit of the lesion extending through the submucosa, the muscularis and even the serosa. In such event, perforation may occur, but most commonly when the peritoneal layer is reached, local, low grade peritonitis sets in and actual perforation may be for a long time prevented. Not infrequently, the perforation is prevented by inflammatory reaction in the peritoneal coverings of adjacent viscera—liver, spleen, pancreas, small or large bowel, or the omentum. Adhesions to these structures follow with fixation of the stomach. Such are often productive of gastric deformity and frequently interfere with proper gastric motor function. Not rarely the peritoneal protection is but temporary. The adhesions give way, fatal peritonitis follows or direct extension of the process occurs into the parenchyma of adjacent viscera, sometimes with resultant abscess or fistula formation. Quite commonly the effects of ulcer extension are more serious than is the actual damage done to the stomach wall by the ulcer. In the healing of ulcers, irrespective of their causes, the essential feature consists in the development of protective connective tissue by hyperplasia or of new mucosa. Scar results and causes destruction of the essential structures forming the gastric wall.

Location.—Nearly 70 per cent. of gastric ulcers lie in the pyloric third of the stomach. Forty-three per cent. actually involve the pylorus, while rather more than 30 per cent. originate on or extend to the lesser curvature. Approximately 6.5 per cent. of the ulcers invade the cardia, having primarily had their origin there or having extended to it from the lesser curve. The posterior wall is the seat of the lesion in nearly 9

per cent. and the anterior wall is involved in rather more than 3 per cent. of instances.

Association of Gastric Ulcer with Other Abdominal Pathology.—Of the cases making up the writer's series above mentioned, in 34 per cent. there was a history of previous appendicectomy, or at laparotomy for ulcer diseased appendix was demonstrated. In 12 per cent., operation for the relief of disease of the gall-bladder, with or without stones, had previously been performed, or at laparotomy for ulcer cholecystitis or cholelithiasis was demonstrated. In other words, in 46 per cent. of the cases of ulcer, inflammatory affections of the appendix or the gall-bladder coexisted at the time that the ulcer was demonstrated or the previous history indicated that the patients had experienced such ailments. This observation is of sufficient importance to warrant emphasis on three points: (*a*) The etiological significance of local foci of disease in the appendix and the gall-tract in relation to coincident or subsequent changes in the stomach wall; (*b*) The prognostic limitations respecting gastric function following appendicectomy, cholecystectomy or cholecystostomy; (*c*) The advisability of careful anamnesis and abdominal examination of individuals whose only ailment, symptomatically appears to be located in the region of the appendix, the gall-bladder or the stomach.

Symptoms.—*Character of the Complaint.*—In nearly 5 per cent. of cases, no symptoms that could be attributed to the stomach lesion were recorded. In such patients, the ulcers were discovered in the course of general examination, laparotomy for other affections or at necropsy. Commonly, however, peptic ulcer is associated with a *dyspepsia*, chronic in duration and intermittently manifested.

Periodicity.—Until complications (stenoses, adhesions, perforations, malignant change) have occurred, 82 per cent. of gastric ulcer cases give histories of discomfort occurring intermittently ("attacks," "spells," etc.). The attacks are variously stated as occurring at intervals of from three to five years, every year or two, two to six months or from two to five weeks apart. They are often noted as lasting but a few hours but the discomfort may persist for weeks or months, the duration being frequently but indefinitely influenced by medical or other treatment.

Character of the Digestive Upset.—The presence of a peptic ulcer produces a dyspepsia in more than 90 per cent. of instances. Patients often appear with a self-given diagnosis of "indigestion," this usually of the chronic type. While "indigestion" is a symptom and not a disease, yet the gastric malfunction of ulcer exhibits certain peculiarities which are of valuable aid in diagnosis.

1. Pain.—It is very uncommon for the peptic ulcer case to be free from some form of discomfort. This discomfort is variously described as "burning" "gnawing" "dull ache" or vague discomfort. In about 20 per cent. of instances there is a history of severe pain ("cramps" "doubling up" "tearing" or "knife-like"). Such acute pains generally indicate marked gastric peristaltic activity or complications such as perforation or hemorrhage. In nearly half of the patients, at times

there are described sensations of "fulness" or "upward pressure." These not usually occur shortly after feeding and are probably caused by increases in intragastric pressure as the processes of digestion are initiated.

Subjective Location of Abdominal Discomfort.—In eight out of ten instances distress is described as being epigastric. It is usually in the midline or somewhat to the right. In about 6 per cent. of cases the distress is beneath the xyphoid cartilage; in 2 per cent. "in the small of the back," in 3 per cent. in the region of the navel and in about 6 per cent., general, throughout the abdomen.

Transmission of Pain.—In more than one-third of instances, the pain is limited entirely to the epigastrium. In nearly 17 per cent. the pain is referred posteriorly to the tip of either scapula, usually the right; in about 11 per cent., to the rib margins, most commonly the right, and in 8 per cent. "burning" or "gripping" sensations are complained of in the lower esophagus, in association with, or following, the epigastric discomfort.

Time of Pain Occurrence.—In nearly 85 per cent. of peptic ulcer cases, the onset of pain occurs in relation to the ingestion of food. In approximately half the cases, epigastric distress begins two to four hours after eating. Less than 15 per cent. of uncomplicated ulcer cases experience discomfort within one hour after eating, provided a diet of moderate bulk is being ingested.

Causes of Pain in Peptic Ulcer.—It was formerly thought that the discomfort occurring when ulcer of the stomach existed was due to food traumatism of the ulcer area, together with so-called (a loosely applied term) "corrosive action" of the gastric juice. Recent researches conducted by Carlson and others, have established the fact that the majority of ulcer patients experience pain, when the stomach is practically empty and when the pepsin-hydrochloric acid content of the gastric juice is considerably below the maximum. Physiological experimentation, particularly that series conducted by Cannon, appears to indicate that much of the peptic ulcer distress can be explained on the basis of exaggerated "hunger contractions" of the stomach wall, coming on generally as the stomach becomes empty. With these "hunger contractions" occur noticeable increases in intragastric tension. This explanation appears to explain the relief of pain in instances of uncomplicated ulcer, by food ingestion and by agents relaxing hypertonic gastric musculature. Food in the stomach relieves the intragastric tension by counteracting the powerful "hunger contractions." It is a significant fact clinically, and strongly emphasized by the researches of Cannon and of Carlson, that quite commonly, the character or the reaction of the ingested food has little bearing upon the relief of the ulcer pain. A meal of mixed food, a glass of alkaline water, a drink of spirits, an opiate or a carminative act equally well. It is a clinical observation, that a bulky meal gives longer continued relief from pain than does a liquid meal of small volume: thus apparently, due to the fact that where there is much food in the stomach, the onset of painful

"hunger contractions" is delayed longer than in instances where a fluid meal, of small bulk, quickly leaves the stomach. From the above, it is readily apparent why the time of occurrence of pain following food ingestion is but a relative, clinical indication of the location of the peptic ulcer. The appearance of "hunger contractions" initiates gastric distress in whatever part of the gastric wall the ulcer is located. The time of appearance of pain is largely dependent upon the nature of the food ingested, bulky meals delaying the manifestations of distress and small meals allowing the pain to appear earlier, provided the ulcer is of uncomplicated type.

Pain Control in Gastric Ulcer.—"Food Ease."—Except where powerful gastric peristalsis is initiated by vagus hypertonia or, reflexly, in association with extra-gastric ailments (appendix, gall-bladder), the relief of pain by the taking of food into the stomach is of considerable diagnostic value, especially so, if this phenomenon is continuously present in attack after attack of dyspepsia. "Food-relief" is noted in nearly 85 per cent. of instances of uncomplicated ulcer. Other forms of pain relief are alkali, lavage, vomiting, fasting, liquors or opiates.

When complications have occurred in the course of an ulcer (stenoses, perforation, malignant change, hemorrhage) or pathology in other abdominal organs has become advanced, complete relief of discomfort is rarely obtained by the above mentioned agents.

2. Vomiting.—About 70 per cent. of peptic ulcer cases, give a history of at some time having vomited sour fluid, food or blood. The vomiting is not uncommonly induced to bring about gastric comfort. Vomiting usually occurs at irregular intervals, provided hour-glass stomach or stenoses are not present. In the latter event, vomiting is a more or less constant happening (*vide infra*, Benign Pyloric Stenosis).

Vomiting commonly occurs within three hours after food ingestion. Where there is much gastric irritability and spasm, the vomiting may occur immediately or shortly after food has reached the stomach. Where ulcers are located near the cardia or at or near the pylorus, the peristalsis initiated during swallowing or when food reaches the stomach, may bring about particularly severe gastric spasms and early vomiting. This may happen even when there is no actual stenosis at either cardia or pylorus.

"Delayed vomiting," *i. e.*, the persistent emesis of food that has lain in the stomach longer than eight hours, is a constant accompaniment of pyloric stenosis or of hour-glass types of stomach, should the patient be kept upon a bulky diet. Occasionally, occur instances of gastric fatigue with resulting atony and dilatation of the stomach where retention vomiting does not signify stenosis.

3. Hemorrhage.—In rather more than 30 per cent. of instances of peptic ulcer, there is a history of the *vomiting of blood* or of the passage of stools containing fresh blood or clots. Certain types of ulcer seem more prone to bleed copiously than do others. This appears to be especially so with respect to ulcers located at the cardia, on the lesser curvature and at the pylorus. The amount of blood lost varies greatly both in

different patients and the same patient in different attacks. It may vary from a few teaspoonfuls to as much as eight quarts. The blood is commonly fluid, but may be mixed with food and, where the hemorrhage is copious, is of alkaline reaction. In about 7 per cent. of instances small or large clots of blood are vomited. These usually occur after the primary hematemesis and may be vomited some time after it has been thought that all bleeding has ceased. This rule is, however, not absolute. Vomiting of clots may precipitate other hemorrhages.

Melena.—Melena may occur wholly irrespective of the position in the stomach wall occupied by the ulcer. Persistent melena without hematemesis commonly indicates an ulcer situated near the pylorus. About 12 per cent. of ulcers that bleed exhibit melena alone.

The stools may be pitch black or slate gray. The entire stool may be discolored at several passages not rarely extending over many days. Portions of the stool may be mixed with red blood or small or large tough clots are scattered irregularly through the feces. Blood-colored stools may appear only after considerable time following actual hemorrhage. If there have been few subjective symptoms at the period of hemorrhage, the blood-stained stool may be overlooked or the melena may be difficult to account for, clinically.

Subjective Evidences of Hemorrhage in Ulcer.—The bleeding may be accompanied by severe colicky, abdominal pain, but in nearly 18 per cent. of cases the patient experiences no particular inconvenience. The hematemesis comes as a surprise during an ordinary vomiting spell or initiates vomiting in the course of a dyspeptic attack. In about 40 per cent. of the cases, there is a feeling of faintness; in a rather larger number actual fainting occurs and symptoms of shock supervene (*vide supra*, Gastric Hemorrhage).

4. Nausea, with or without vomiting, is not rarely annoying. It occurs in more than 20 per cent. of cases. It commonly occurs within two hours after eating a meal of moderate bulk, but may be experienced almost constantly.

5. Pyrosis, Eructations, or "water brash" are frequently distressing during "spells" or "attacks" of ulcer dyspepsia. Such symptoms may be entirely absent in the intervals between attacks. When stenosis has supervened, then the patient may be constantly affected. Sometimes nocturnal pyrosis and "water brash" are especially distressing.

6. Bowels.—Nearly 60 per cent. of ulcer patients are constipated. Sluggishness of the bowels may precede the periodic attack of dyspepsia. Free catharsis may ward off the gastric upset or render the discomfort less. When stenoses exist, constipation, due to partial starvation, may be obstinate. Diarrhea is associated with ulcer dyspepsia in about 11 per cent. of patients. It is probably caused by rapid gastric emptying, complications involving the pancreas or the gall-tract, deficient gastric or duodenal secretions, putrefactive processes in the bowels, or to imperfect vagus or splanchnic function.

7. Appetite is maintained in more than one-third of the patients, even during the dyspeptic storms. Not uncommonly the dread of

bringing on pain explains a poor-appetite habit. However, most ulcer patients are large eaters, often in spite of warnings. In their periods of good digestion, they readily forget admonitions against excesses and partake greedily of foods that tickle their palates. In instances of stenosis, the appetite is capricious, or it is restrained through dread of precipitating an attack of vomiting. Not infrequently, however, even such sufferers eat heartily and rely upon relief from the use of the stomach tube.

In a few instances appetite is poor from the beginning of the affection. Females are apt to exhibit this anorexia more commonly than are males. When *ulcus carcinomatosum* is present, capricious or constant poor food-desire may be sufficiently striking to assume the importance of a diagnostic hint.

8. WEAKNESS, HEADACHE and MALAISE are commonly complained of in those affected with peptic ulcer. Anemia, weight-loss, starvation, disturbed sleep, exhaustion from prolonged pain or vomiting, constipation and lack of exercise account for the physical unfitness.

Signs of Peptic Ulcer.—(1) **Physical Examination.**—(*a*) *Nutrition.*—Until complications set in, the ulcer patient is generally well nourished: he rarely exhibits a toxic or cachectic appearance. During attacks or "spells" of dyspepsia, weight is commonly lost. In a series of 500 operatively demonstrated cases of gastric ulcer studied by the writer, weight loss averaged 18.2 pounds. The minimum loss was 5 pounds; the maximum 65 pounds. Some patients lose weight with striking rapidity. However, even marked decrease is rarely associated with the cachexia, common to malignancy: the patients *appear starved but not toxic.* Night pain, with loss of sleep, constant discomfort with the fear of aggravating such by eating, caution in diet as a result of previous hemorrhage and annoying nausea, eructations or vomiting are prominent factors in producing rapid weight loss.

Sometimes weight gain is constant in spite of a distressing ulcer syndrome: patients discover that eating relieves pain and overfeed as a result. This occurred in nearly 8 per cent. of the writer's series.

Malignant degeneration, pyloric or cardiac stenosis or interference with the free passage of food through the gastric lumen (hour-glass, diverticula-like sacculations) is commonly accompanied by persistent and steadily progressive weight loss.

(*b*) *Abdominal Tenderness.*—In more than 90 per cent. of gastric ulcer patients, some degree of discomfort is experienced upon abdominal palpation. The entire epigastrium may be tender to either light or firm pressure. In 7 out of 10 cases, the areas of tenderness are at or to the right of the midline. In approximately 11.5 per cent. the point of maximum distress is to the left of the midline. Tender ridges are palpable in about 2 per cent. of cases. They are commonly associated with large, chronically perforating ulcers which have extended outward to the peritoneum. In patients with low-lying stomachs the abdominal tenderness on palpation may lie below the navel. In the writer's series this finding was recorded in rather more than 3 per cent.

The relation of areas of abdominal tenderness to the situation of ulcers in the stomach wall is of but relative significance. While it is true that seven out of ten patients exhibit epigastric distress upon palpation of the midepigastrium, and that in this zone is commonly situated the pyloric third of the stomach which is the seat of two-thirds of the peptic ulcers, yet tenderness in this region does not of necessity absolutely indicate the existence or the location of ulcer. Such areas of tenderness are quite frequently found in instances of gall-bladder disease, duodenal irritability or ulceration, pyloric spasm, right kidney and pancreatic ailments, inflamed peripyloric lymph nodes, chronic constipation or appendicitis. It would, therefore, appear that only when taken into consideration with numerous other clinical observations, are points of abdominal tenderness of real worth toward actually indicating the positions in the gastric wall at which ulcers are located or that ulcer is actually present. It requires but a brief experience at the laparotomy table to further emphasize this statement.

Perforating ulcers, or ulcers which have frequently bled, are commonly the seat of well-delimited abdominal tenderness. This type of ulcer usually brings about inflammatory reactions in the overlying peritoneum, with resultant distress to even light palpation. When protected perforation has occurred, well walled off by peritoneal adhesions, the anomalous manifestation of a locally acute abdominal condition in a patient with an otherwise chronic abdominal disturbance, is quite striking. Such areas of local peritonitis are often exquisitely tender to touch, and if pus has accumulated fluctuation and dulness to percussion may be evident. Usually, however, spasm of the overlying muscles of the abdominal wall prevent accurate delimitation of the area actually involved and frequently, but not always, exaggerate the picture, clinically. If perforation of a peptic ulcer takes place without peritoneal walling off, then the freed contents of the stomach rapidly produce general peritontitis with fatal result, even though prompt surgical aid be obtained. This complication is particularly serious where ulcers are located on the anterior wall or the greater curvature of the stomach.

(*c*) *Dilated, "splashy stomach"* can be demonstrated in instances where pyloric stenosis is of extreme grade and when muscular fatigue has resulted in gastric atony. At times moderate stenoses caused by *ulcera carcinomatosa* produce gastric atony, apparently as a consequence of toxic substances acting on the muscle bundles or upon the nerve-endings. In such event, although there may be a lumen of considerable caliber to the pyloric channel, food retention, with splashing sounds on tapping in the region of the stomach, may be pronounced.

(*d*) *Visible peristalsis* is observed where stenoses of an obstructive degree are associated with a gastric musculature as yet unfatigued. The stomach is commonly enlarged, but of a tone even greater than normal: the obstructing lesion has the primary effect of a stimulus to the gastric motor mechanism.

Visible peristalsis occurs in about 11 per cent. of instances of

benign pyloric obstruction. If the patient be not too fat, waves or bulges pass slowly across the abdomen from left to right at the rate of from 3 to 7 per minute. The stomach contour may be well outlined to the eye. If the subject be thin and the observer of keen vision, the "piling up" of peristaltic waves as well as the forward and downward rotation of the stomach, may demonstrate a tumor-like ridge in the region where the pylorus is judged to lie. "Reverse" peristaltic waves (*i. e.*, passing across the abdomen from *right* to *left*) are occasionally noted.

Visible peristalsis does not of necessity indicate pyloric stenosis. Instances of marked gastric hyperesthesia, not uncommonly associated with aërophagia, may exhibit pronounced gastric peristaltic unrest, even though there be no demonstrable lesion in any part of the stomach wall.

(*e*) *Local foci of infection* apart from the gastric affection, are not infrequently found concomitantly with peptic ulcer. They should always be searched for. It is quite likely that even foci of infection far removed from the stomach, in a given individual, may have had etiological influence toward the production of an ulcer or in preventing its proper healing. Such foci are often found in the nose, head sinuses, about teeth, or in tonsillar or pharyngeal adenoid tissue. Intra-abdominally, an infected appendix or gall-tract or abdominal lymph nodes may, continuously or periodically, feed microörganisms to a damaged gastric wall. At times, it is perhaps of greater importance to discover these chronic germ centers and to eradicate them than it is to direct special therapeutic measures toward the peptic ulcer itself.

(2) **Laboratory Examinations.**—(*a*) *Blood.*—In chronic peptic ulcer or acute peptic ulcer associated with hemorrhage or starvation, a mild anemia is demonstrable. The hemoglobin averages approximately 70 per cent. in a considerable series. The number of red cells is usually reduced, but show by the stained blood smear characteristics of a mild secondary anemia. Leukocystosis of moderate degree is common, but in the non-perforative type of ulcer, it rarely exceeds 12,000. Where perforation exists, with local or general peritonitis, the increase in leukocytosis is early and marked. The differential count reveals an excess of polymorphonuclear cells.

Serological blood tests should be made routinely upon all ulcer cases. Recent studies of gastric syphilis indicate that luetic ulcerations are by no means so rare as was formerly considered.

(*b*) *Test-meal Evidence.*—(1) *Gastric Retention.*—A motor meal of bulky nature should be employed to prove whether or not the gastric lumen is freely patent or gastric atony exists. (*Vide*, Methods of Examination, page 575.) When such meal is employed, more than three-fifths of chronic ulcers are associated with some degree of eight- to twelve-hour food retention. The retention may be due to persistent, local, (pylorus) or general, gastric spasm, organic obstruction, or a combination of these factors. Hypersecretion of gastric juice and mucus may coexist, although it is quite likely that many instances of so-called "ulcer hypersecretion" represent mild stenoses complicated

by pyloric spasm. Similar findings are not unusual in such extragastric ailments as intermittently active disease of the appendix or the gall-tract. Confusion is easily possible when such affections complicate peptic ulcer.

(*c*) *Acidity of Gastric Extracts.*—The quantity of the fasting stomach contents may be increased. An increase over the normal 20 to 50 c.c. is not uncommon. Amounts exceeding 100 c.c. are indicative of hypersecretion, stenosis or spasm with definite food stagnation. In this type of case, free HCl averaged 56.4 and total acidity 74.2 in the writer's study of 336 instances. In the non-retention or atonic group of ulcers (164 cases) the free HCl averaged 40.5 and the total acidity 52.4. Gastric extracts exhibiting absent free HCl are occasionally met with in ulcer cases, even when the affection is benign. It is a mistake to expect abnormally high free HCl estimations to characterize peptic ulcer. Less than a third of 500 operatively demonstrated instances of the affection studied by the writer exhibited free HCl in excess of 50. The newer investigations of Rehfuss, by the ingenious fractional method, serve to emphasize how little is actually known regarding gastric acid variations in health and disease, and how great may be the variations in acidity in the same individual examined at different *seances*. It is thus apparent how limited, diagnostically, are estimations of gastric acidity in peptic ulcer. Such should not be neglected, however, as without them but an imperfect knowledge of stomach function is possible.

The highest gastric acidities in the writer's series of ulcers were quite uniformly returned from instances of acute and subacute perforating ulcer. In the ordinary chronic ulcer, the acidity figures closely resemble such as are returned by cases of chronic gastritis and early *ulcera carcinomatosa*. Where gross hemorrhage has recently occurred there is an average reduction in free HCl acidity of approximately 10.

(*d*) *Macroscopic blood* or positive chemical tests for blood in gastric extracts are recorded in rather more than one-third of peptic ulcer cases. Frequently the blood results from stomach-tube manipulation or chemical test is positive as a consequence of stagnant food remains. Often the demonstration of blood in stomach extracts is of no significance in proving the presence of a gastric ulcer, nor is a negative test evidence that ulcer is absent. In malignant ulcers, chemical tests for blood in gastric extracts are almost constantly positive.

The "string-stain test" for locating the position of an ulcer in the gastric wall and for determining its histological state, is a deceptive toy. The writer's observations with this test upon 318 operatively proved instances of peptic ulcer convinced him of the uselessness of the procedure. The test was positive 17 times. Laparotomy was not uncommonly negative in cases where the string-test had been definitely positive.

(*e*) *Stools.*—Negative chemical tests for blood in stools does not indicate absence of gastric ulcer. Chronic ulcers bleed but intermittently if malignancy is lacking. Consequently, even though the stool be care-

fully prepared for analysis, negative tests are quite apt to be recorded. In periods of ulcer dyspepsia, when stools are collected after the patient has been on meat- and green-vegetable-free diet for at least two days and upon milk or cereal gruel diet for twenty-four hours preceding the actual collection of the specimen, positive "occult" blood tests were obtained from 39 per cent. of cases in the writer's series. The chemical finding of altered blood in the stools of a patient *with an ulcer type of dyspepsia* is of more significance with regard giving information respecting the histological state of such ulcer, than it is in informing one that ulcer is present. In malignant ulcers, altered blood can be demonstrated constantly in the stools of more than 95 per cent. of cases. Almost two-thirds of benign gastric ulcers must be diagnosed without positive chemic test for blood in the stools.

(3) **Roentgen Evidence of Gastric Ulcer.**—At surgical clinics, the *x*-ray examination of chronic ulcer cases returns evidence of considerable relative clinical worth toward rounding out diagnoses. This has led to an exaggerated opinion of the value of the method as an aid to diagnosis of peptic ulcer generally. In uncomplicated gastric ulcer, the value of either fluoroscopy or serial radiography is chiefly inferential. By uncomplicated peptic ulcer is meant ulcer in which pyloric or cardiac stenoses have not occurred, where hour-glass contraction has not taken place or where malformations in the stomach's contour have not resulted as a consequence of crater formation, perforation, adhesion, fixation or fistula. In surgical clinics, such accidents in the course of gastric ulcer occur in about 60 per cent. of ulcers; in general diagnostic clinics, the routine run of cases exhibits a much less frequent incidence.

It is evident that positive roentgen manifestations of peptic ulcer furnish a valuable aid in quickly segregating the group of ulcers likely to be most greatly benefited by surgical procedures from that upon which non-surgical therapy is indicated. The decision lies in the roentgen proof of gastric deformity. It is thus seen, that in surgical clinics where this fact has been appreciated, the laparotomy findings will roughly agree with the roentgen reports, in a high percentage of cases. Carman states that of 47 instances where ulcer was found at laparotomy 30 (83 per cent.) were diagnosable upon radiologic evidence. The percentage is not given with respect to absence of ulcer at laparotomy where radiologic signs had pointed to the presence of such, nor is it stated in how many instances clinical diagnosis of peptic ulcer had been made without the radiological report being considered. No statistics are furnished relative to how many patients negative for ulcer by roentgen study, were proved to have ulcer at operation, or by clinical history and later observation. Carman's experience is quite similar to that of other technicians whose work is checked up either by laparotomy or by autopsy.

The roentgen signs of gastric ulcer are (*a*) inferential and (*b*) positive.

(*a*) *Inferential Signs.*—(1) Incisura, *i. e.*, local evidence of persistent indrawing of a portion of the stomach contour. It should be proved

to remain after physiological tolerance to atropin or belladonna has been reached. It is thought that an "incisura" is due to local halting of peristalsis by spastic contraction of the muscle-bundles in the vicinity of an ulcer (Fig. 253).

(2) "Hour-glass" stomach. (Biloculation). This may be permanent (callous ulcer, perforation, adhesion) or transient (local spasm, with or without ulcer). It may vary in degree on repeated examination (Fig. 254).

(3) Gastric residue, *i. e.*, opaque substance retained for six hours or longer in the stomach. The residue may vary in amount. Unless marked gastrectasia exists, the amount of six-hour residue furnishes a

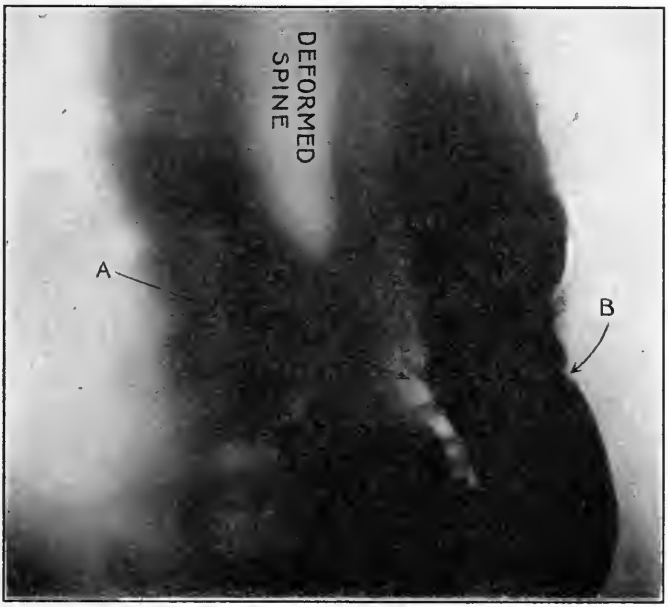


FIG. 253.—Small lesser curvature ulcer, causing no pronounced deformity but exhibiting one of the inferential signs, roentgenologically, viz., greater curve "incisura." *A*, site of non-deforming lesser curve ulcer; *B*, incisura. (Original observation by author.)

rough index of the degree of obstruction. The six-hour residue should be proved to be a constant finding upon repeated examinations. Intermittent, six-hour residues are not uncommon in association with extragastric pathology (duodenal ulcer, disease of the gall-bladder, appendix, peripyloric lymph nodes or the right kidney.) or marked ptosis with or without gastric atony.

(4) Fixation of all or part of the stomach to adjacent viscera (perforation, fistula, adhesions) (Fig. 255).

(5) Area of tenderness to palpation during fluoroscopic examination. This may be persistently localized at some part of the stomach shadow

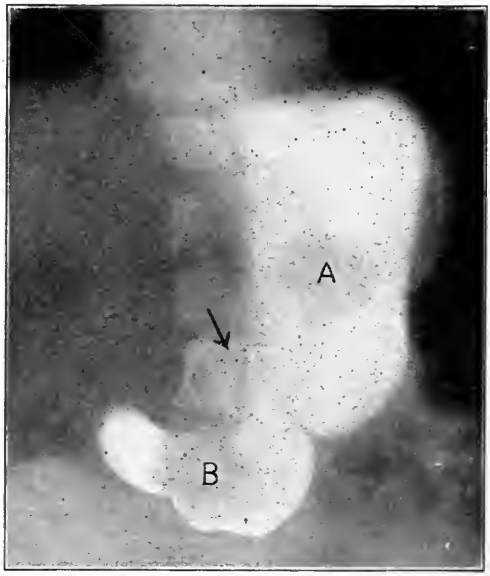


FIG. 254.—Saddle-ulcer on lesser curvature of stomach (shown by arrow) with "hour-glass" formation: *A*, large upper loculus; *B*, smaller, lower loculus. (Original observation by author.)

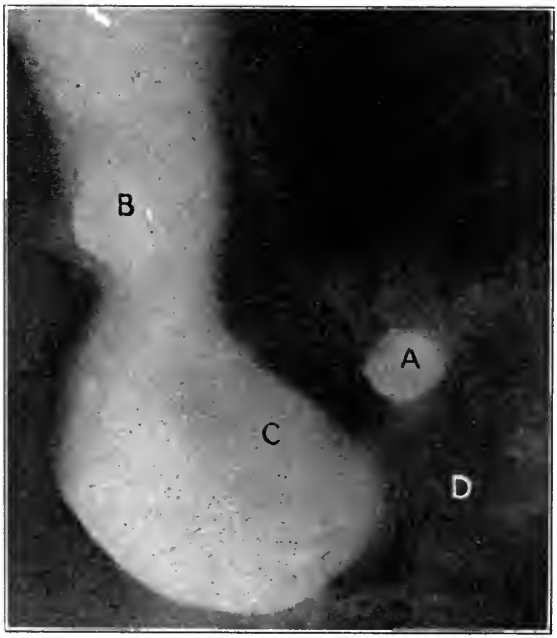


FIG. 255.—Penetrating, greater curve ulcer (*B*) adherent to spleen capsule; a second ulcer at pylorus, lying between duodenum (*A*) and pars pylorica (*C*), deeply adherent to head of pancreas. *D* is partly visualized duodenum. (Original observation by author.)

even after physiologic tolerance to antispasmodic medicines has been reached.

(6) Alterations in gastric peristalsis, viz., exaggerated peristalsis, frequently associated with firmly maintained, spastic closure of the pylorus (rarely, the cardia). Antiperistaltic waves are sometimes observed (Fig. 256).

(*b*) *Positive Signs.*—Carman emphasizes, after careful study of a large material, that the "niche" and "accessory pocket" are the only conclusive radiologic signs of peptic ulcer. Such are found in association with calloused crater-ulcer, perforating ulcer or following fistulæ.

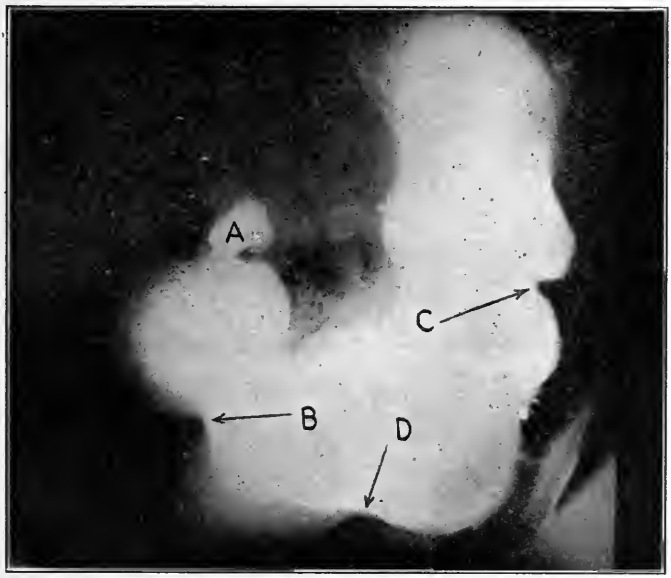


FIG. 256.—Obstructing, pyloric ulcer (*A*), with excitation of vigorous, hyperistalsis (waves at *B*, *C* and *D*) in a stomach whose musculature is, as yet, unfatigued. (Original observation by author.)

The *size* of the "niche" or "accessory pocket," as demonstrated radiologically, has a considerable value apart from proving that ulcer exists (Fig. 257). A large crater is often found when the ulcer is malignant. It has been shown by the surgical pathologist that chronic, calloused ulcers, whose craters exceed 2 cm. in diameter, are malignant in more than six out of ten instances. Hence the radiologic demonstration of a "niche" exceeding 2 cm. in diameter permits a tentative diagnosis of *ulcus carcinomatosum*. In fact, such observation really comprises the earliest possible, roentgen diagnosis of gastric cancer (Fig. 258).

In cases where clinical history of peptic ulcer is clouded by the presence of other abdominal pathology, the roentgen demonstration of

FIG. 257.—Penetrating ulcer on lesser curvature, showing crater, or "pocket," filled with barium. Roentgen observation meal: A "positive" sign of ulcer of the stomach. (*A*, penetrating, greater curve ulcer, with accessory "niche"); *B*, area of muscle spasm. (Original observation by author.)

FIG. 258.—Pyloric ulcer causing partial obstruction, and of such extent as to invade pyloric sphincter and *pars pylorica* (arrow, A). *B*, dilated, slowly emptying duodenum; *D*, visualized jejunum (arrow, D). (Original observation by author.)

crater-ulcer in the stomach is of much worth. In this event, the actual location of the ulcer is determined previous to laparotomy and a different prognosis can be given from that which would be offered were the lesion on the duodenal side of the pylorus.

Complications.—(1) *Pyloric Obstruction.*—This occurs in approximately 25 per cent. of instances of the affection. Its clinical manifestations are fully considered in the section on Benign Pyloric Stenosis (*vide infra*, page 633.)

(2) *Hour-glass Contraction.*—The surgical treatment of peptic ulcer has demonstrated a greater frequency of this complication than was formerly considered to exist. Nearly 10 per cent. of gastric ulcers of a chronic nature produce hour-glass. The contraction may occur at almost any part of the viscus but usually takes place at the pars media or distal to it. It is thus evident, that loculi of unequal size may be present. The greater loculus is most commonly toward the cardia because the greater number of gastric ulcers occur toward the pylorus. While peptic ulcer may primarily initiate hour-glass formation, the malformation may be greatly exaggerated as a consequence of perforation or adhesions with or without extensive fixation of the stomach to adjacent viscera (Fig. 254).

Symptoms and Signs of "Hour-glass" vary. There is commonly a long history of peptic ulcer, early intermittent in its manifestation but later continuous. Obstructive vomiting and evidences of gastric retention (food stagnation, weight and strength loss, constipation and diminished urine output) are present. The test meal may reveal twelve-hour food retention, increase in free HCl, blood-stained gastric extracts or, microscopically, an excess of budding yeasts and sarcinæ. Physical examination may demonstrate tender abdominal (usually epigastric) ridge, splashy stomach or anomalies in the auscultatory murmur when the stomach is filled with air or water through a tube. Upon gastric lavage, a large amount of fluid may be poured into the stomach and but a small quantity be recovered, or when the stomach is emptied, contents are first obtained which differ in quantity and kind from those secured toward the end of the procedure. (Woelfer). If the stomach be inflated rather tightly with air, an anomalously shaped viscus may be seen in the epigastrium. Again, one part of the distended stomach may contain air only, while the other may contain both air and fluid. Over the latter portion, splashing sounds are heard when the abdomen is vigorously tapped. (Taworski.)

Fluoroscopic or roentgen plate examinations usually give ocular proof of the presence of a biloculated stomach and may definitely indicate the cause of such. Comparison of the radiological findings before and after the use of antispasmodic medicines (atropin or belladonna) is necessary to eliminate errors possible from powerful gastric spasm, with or without peptic ulcer.

(3) *Malignant Metamorphosis in Peptic Ulcer.*—This subject is considered in detail on page 640. (The Relationship Between Gastric Ulcer and Gastric Cancer).

(4) *Perforation.*—Protected perforation is common during the course of chronic gastric ulcer. It occurs in from 20 to 25 per cent. of instances in surgical services handling ambulatory material. Its incidence is probably lower if considered in connection with all types of gastric ulcer.

Chronic protected perforation commonly gives rise to no symptoms differing from those associated with progressive, gastric ulcer in general. If closely questioned, patients may give histories of particularly severe attacks of dyspepsia, often associated with cramp-like, abdominal pain and may indicate that such attacks have occurred frequently during the recent course of the ailment. At times, gross hemorrhage may complicate the periods of acute distress. Frequent hemorrhages furnish significant information, even though abdominal pain may not have been severe. Where such have occurred, fully 60 per cent. of ulcers reveal some grade of perforation at laparotomy.

Acute perforation complicates about 3 per cent. of ulcers. There may have been but few symptoms of dyspepsia previous to the initial sudden, sharp, doubling-up, prostrating pain. In other instances, the acute crisis happens as a new event in the course of an ordinary ulcer attack. Gross hemorrhage (hematemesis or melena) may occur concomitantly.

The main characteristic of acute perforation is sudden, severe pain. It is usually epigastric. Initially well localized, later it assumes aspects of a continuous, general, hard "belly-ache." Fixation of the abdominal muscles, pallor, shock, subnormal temperature at first, (later high fever), and associated peritonitis, follow. Vomiting may be obstinate and exhausting. Leukocytosis, chill or chilly sensations, and evidences of exudate in the peritoneal sac rapidly supervene unless immediate aid can be secured. Occasionally, extensive peritoneal involvement is prevented by a bit of omentum or an adjacent viscus plugging-up the ulcer base. In such event, localized peritonitis occurs, the escaping contents of the stomach are walled off and although abscess or fistula may develop, the patient frequently recovers.

(5) *Hemorrhage.*—The clinical features of this complication are considered fully on page 612. (Gastric Hemorrhage.)

(6) *Adhesions.*—Perigastritis sometimes occurs without its resulting as a consequence of perforating ulcer. In such event, inflammatory change in the subserosa follows chronic, bacterial activity in the lymphatic channels. While the streptococcus is the most frequent organism associated with perigastritis, yet the greatest degree of gastric deformity occurs in luetic affections.

The effect of perigastritis is to produce gastric deformity. This deformity varies greatly in degree. There may be irregularities in gastric contour, marked thickening of the stomach wall, or adhesions so that the inflammatory process involves adjacent tissues (pancreas, large or small intestine, liver, spleen or omentum). Commonly, scar-tissue develops early. The contraction of scar-tissue often results in fixation of all or part of the stomach to adjacent organs, with consequent displacement of the viscus and resultant deformity.

In rare instances, where there is rapid spread of invading organisms under the serosa, actual purulent peritonitis follows. There may then occur numerous *abscesses* in the wall of the stomach or about it.

The diagnosis of perigastric adhesions is most accurately made at laparotomy. Fluoroscopic examination may, however, show malformations in gastric contour, displacement of the stomach, or adhesions to neighboring viscera.

BENIGN PYLORIC STENOSIS.

Incidence.—Of 8581 patients with digestive upsets, and upon whom gastric as well as general examinations had been made by the writer, there were 698 such individuals (8.1 per cent.) affected with some type of benign, pyloric stenosis. Definite proof of the nature and degree of the pyloric narrowing was possible at laparotomy or autopsy in 622 cases (89 per cent.). In the remaining patients, history, clinical examinations and subsequent course were reasonably definite toward establishing the non-malignancy of the ailment.

Causation.—Pyloric stenosis most commonly results from peptic ulcer, duodenal or gastric (84 per cent.). Occlusion of the gastric exit varies greatly in degree and extent: at times, there occur local or tubular constrictions amounting to nearly complete obstruction; again, patches of fibrous, ulcer base are surrounded by dense, hypertrophied muscle bundles and excessively vascularized, edematous, areolar tissue and mucosa, with moderately patent lumen; or small, puckered ulcers result in marked tortuosity or fixation: the pyloric orifice is then stenosed only as a consequence of inflammatory reaction about, and sometimes quite distantly removed from, the ulcer itself.

In their order of frequency, causes of benign pyloric stenosis other than ulcer were: gall-bladder disease and its complications, myomatoid hypertrophy of the pyloric and antral musculature (apparently consequent upon long maintained pyloric spasm), gastric syphilis, enlarged peripyloric lymph glands, ailments of the pancreas (chronic inflammation, cyst, gumma), cirrhosis of the liver, hepatic syphilis, hydronephrosis of right kidney, foreign body in the stomach, gastric myoma, pyloric polyp, volvulus (infant), cyst of the liver, pyloric varicosities and aneurysm of abdominal aorta.

Effects of Pyloric Stenosis.—(*a*) *Local.*—The patency of all or part of the pyloric lumen is interfered with. The stricture may be so small as to admit but a probe. There may be several points of narrowing, with ampulla-like spaces between. The stenosis not infrequently extends so as to involve the pyloric fourth of the antrum or the first third of the duodenum. Quite commonly, the actual narrowing of the pyloric channel as a result of scar-tissue in the wall of the stomach may be of relatively low degree, but when muscle spasm is associated with it, such stenosis may be nearly complete. Perforation, with gastric fixation or malformation, may further aggravate the local pyloric defect.

Pyloric obstruction cannot long continue, even of low grade, without a definite reaction taking place in the entire stomach. This reaction occurs as a consequence of a demand for increased gastric function. Not only must food be more than ordinarily chymified to facilitate its passage through a narrow exit, but added muscular effort is needed in order that the chyme may freely negotiate the stenotic pylorus. Very early, are observed congested, thickened gastric mucosa, edematous, areolar tissue and hypertrophied musculature. If the stenosis increases in degree, muscular hypertrophy reaches its limit and atony and dilatation of the stomach result. The mucosa and submucosa then become thin and atrophic. Persistent food stagnation follows.

(*b*) *General.*—Systemic malnutrition early becomes manifest. Dry skin and mucous membranes, anemia, muscular flabbiness, loss of panniculus, weakness, decrease in weight, intestinal atony, diminution in urine output and mental sluggishness are soon apparent as a consequence of insufficient food assimilation, constant discomfort or pain and loss of sleep.

Symptoms.—(*a*) *Vomiting.*—The patient may have previously experienced occasional attacks of vomiting at the time of an aggravation of his dyspepsia. *The characteristic of vomiting associated with pyloric stenosis is that, when the diet is of moderate quantity and normal consistency, emesis is a routine and generally, daily event.* Small, infrequent meals of the pap variety may for a long time mask the clinical evidences of pyloric narrowing and gastric dilatation. On such, a patient may actually gain weight and strength and both he and his medical adviser long remain under the impression that "cure" of such ailment as stenosing ulcer is being brought about. However, just so soon as a meal of ordinary size and consistency be given, retention is proved by prompt vomiting. Patients frequently find this out themselves. Doctors, not rarely, ignore this obvious effect of full feeding and consider the vomiting as being due to "an indiscretion in diet." The "indiscretion" can often be laid to the medical adviser, for while he is relieving the patient in numerous "indiscretions," not infrequently, pyloric stenosis is becoming more marked, gastrectasia of greater degree, or accidents such as perforation, hemorrhage or malignancy are being catered to.

In pyloric narrowing, vomiting is usually daily, and most frequent in the afternoon or evening. If dilatation of the stomach is pronounced and muscular weakness has supervened, then night vomiting or vomiting of large quantities of material several times weekly are commonly experienced. The characteristic feature is that instead of being an *intermittent dyspeptic* with only occasional periods of vomiting, the patient becomes a *constant dyspeptic* with regularly recurring vomiting when fed on food of ordinary bulk. In no type of gastric malfunction are cause and effect so clearly manifest.

The *vomitus* is generally copious. It is composed of poorly broken up lumps of food intermixed with mucus. Its *color* varies with the food eaten. Its *odor* is usually yeasty and but rarely acrid or rancid

as in the event of malignant stenosis. The odor is generally so characteristically yeasty (indicating simple fermentation), that upon this observation a fairly accurate, rapid diagnosis between benign and neoplastic disease may be made. When stomach contents are not obtainable, then the yeasty odor of a chronic dyspeptic's breath has valuable diagnostic significance. The so-called "old-fashioned" physician who made a practice of smelling the breaths of his gastric patients was certainly justified in so doing. It was possible for him to obtain considerable information quickly: certainly, as much information as often follows many of our modern "refinements of diagnosis."

Evidences that food eaten longer than twelve hours previously *persistently appears* in the vomitus or gastric extracts indicates definite organic interference to the passage of food through the alimentary canal. The most common cause for such interference is benign pyloric stenosis. *Pyloric spasm* patients vomit retained food intermittently; *pathologic pyloric narrowing* always causes "delayed" vomiting of retained food when the patient is on a bulky diet. Pyloric spasm may be associated with pyloric stenosis. In such event, while the quantity of the retention-vomitus may vary at different examinations, the factor of food stagnation is a constant one.

Vomiting in pyloric stenosis is a painful act just so long as gastric musculature is not atonic. The pain is commonly most annoying previous to or during the emesis. When the stomach is emptied, the patient is usually comfortable. Gastric lavage may ward off attacks of vomiting. In such way, this procedure often assumes the dignity of a therapeutic or even curative maneuver. While lavage is justified as a measure toward relieving a sufferer, its careless use may for a long time mask a diagnosis and lead to the establishment of a sense of false security.

Constant vomiting limits body nourishment. *Weight loss* logically follows. In our cases of benign pyloric stenoses, it averaged twenty-one pounds. The weight loss may be quite as great as in malignant disease. However, while pyloric stenosis patients usually look starved, they rarely have added to this unfed appearance the evidences of systemic poisoning, such as rapidly dominates the picture in malignancy. Only rarely does gastric stagnation of the benign type lead to intoxication of such marked grade as to produce *tetany*.

(*b*) Persistent, copious vomiting depletes the body tissues of fluids. As a consequence, *diminished urine output* and *constipation* are common secondary symptoms in benign pyloric stenosis.

Eructations, pyrosis, "water-brash" and *regurgitation* were distressing enough to warrant special mention in 57 per cent. of our cases. Commonly, these symptoms were most annoying later in the day than the midafternoon. They were sometimes particularly severe at night, especially in that group of individuals whose stomach musculature was not of sufficient strength to permit easy vomiting.

(*c*) *Gross Hemorrhage.*—This occurred in 31 per cent. of our ulcer cases. Not rarely, bleeding followed excessive vomiting and retching. Only three patients succumbed to severe hematemesis.

When gastrorrhagia occurs in association with pyloric stenosis, the blood vomited may be mixed with food and mucus. It is commonly unclotted and has acid reaction. Later vomitus may be made up of large tough clots. It is then generally alkaline and food-free.

(*d*) *Pain.*—Some form of abdominal discomfort was experienced by 98 per cent. of our patients. When pyloric stenosis is associated with active, open, peptic ulcer then the abdominal distress may be extreme. This is due largely to excessive pyloric, gastric or duodenal spasms and not to food passing over the ulcer itself. The pain is often greatest when the stomach is empty. At such time, abnormally vigorous "hunger contractions" occur, as pointed out by Cannon. Night pain, after emesis, may be so severe as to require opiates, particularly in the early stages of pyloric stenosis, when compensatory hypertrophy of the gastric musculature is being established.

When gastric atony, with consequent stagnation, has occurred, the abdominal discomfort is variously described as a "load," "fulness," "up-pressure," "bloat," "soreness" and "ache."

Signs of Benign Pyloric Stenosis.—(*a*) We have already commented upon the systemic effects of benign narrowing of the pyloric orifice. It is only necessary to emphasize the evidences of emaciation without obvious cachexia, the dried out body-tissues, the weakness, anemia and the so-called 'dyspeptic facies': sallow, drawn face skin, exaggeration of normal wrinkles delimiting muscles of expression, dropped mouth corners, dried lips and lack-lustre, sunken eyes. Jaundice is rare. It may complicate a perforated pyloric ulcer, where the common duct is involved, an old gall-bladder ailment or an enlarged pancreas.

(*b*) *Visible Gastric Peristalsis.*—Visible gastric peristalsis was a sign of diagnostic significance in rather more than 11 per cent. of our cases. It occurs as a consequence of a stout, gastric musculature endeavoring to force chyme through a narrowed, stomach exit. When gastric atony and dilatation supervene, visible peristalsis is rarely present. In favorable cases—*i. e.*, where the abdominal wall is thin and peristalsis is vigorous—waves or bulges pass across the epigastrium or navel regions, from left to right, at a rate of from 3 to 7 per minute. The entire stomach contour may be definitely outlined to the eye. Not rarely, there is not a definite sequence of waves, but numerous, apparently uncoördinated, rounded epigastric bulgings. If the subject is thin and the observer's keenness of vision be properly intermixed with imagination, following strong peristaltic waves, a tumor may appear in the region where the pylorus is supposed to lie. In infants affected with hypertrophy of the pyloric sphincter and stenosis, such a tumor, appearing soon after food ingestion and before emesis, is of much value with regard to both diagnosis and prognosis.

(*c*) *Abdominal Palpation.—Tenderness to* pressure in the right, upper quadrant was noted in 79 per cent. of our cases. It was most pronounced in instances where the cause of the stenosis was active or perforating, peptic ulcer, distended gall-bladder or inflammatory disease of the peripyloric glands or the pancreas. When gastric fer-

mentation is very pronounced and the stomach is more or less constantly distended, the associated gastritis (and probably, gastric myositis), results in the entire gastric zone being tender to even light palpation.

(*d*) *Palpable Ridge or Tumor.*—Palpable ridge or tumor occurred in 18 per cent. of our patients. Such ridges were generally due to calloused peptic ulcer associated with much scar tissue or protected perforation. On several occasions, a large gall-bladder, a group of swollen lymph nodes or an inflamed pancreas suggested the probability of a neoplasm.

(*e*) *Splashy Stomach.*—Splashy stomach is commonly demonstrated when the stomach is partly filled with fluid contents and air and when the gastric walls are atonic or not in active spasm.

Test-meal Observations.—(*a*) *Motor Meal.*—Apart from the clinical observation of retention-vomiting, no procedure is of greater diagnostic worth toward the proof of the existence of pyloric stenosis, than is the demonstration that test-food *persistently* lies in a stomach longer than ten hours. A proper *motor test-meal* must be composed of food that is palatable, harmless and *bulky*. Motor test-meals of the baby-pap variety are of little service.

A routine procedure is to clean the patient's stomach by lavage and then administer 2 ounces of castor oil to empty the intestines. The latter facilitates accurate abdominal palpation. Two hours after the castor oil has been taken, the patient is given a full dinner of foods that he likes. The meal must contain, however, two slices of cold meat (rare beef preferred) and two leaves of lettuce or stalks of celery. Milk or weak tea is allowed, but coffee, cocoa and chocolate are forbidden. Two hours after this meal has been eaten, the patient is directed to eat twenty raw raisins. The skins particularly are swallowed. If the patient vomits, note is made and the vomitus is saved for examination. No other food is given. Twelve hours after the dinner has been eaten and ten hours after the raisins have been given, the stomach is emptied with the aid of a tube of large caliber. A tube of small caliber may empty the stomach of fluid contents, but leave behind retained material that has been poorly broken up. Gastric lavage, with an abundance of warm salt solution, should always follow the securing of the fasting stomach contents. If such is not carried out, then stagnation material retained in loculi (perforation crater, hour-glass, diverticulum, etc.) may be missed or mucus-mixed, firm food masses, lying deeply in low, atonic stomachs, may be left behind.

Interpretation of motor meal results by the above procedure is comparatively simple. If food is *constantly* found to lie in the stomach for longer than ten hours, the cause lies commonly in some form of organic obstruction. This is, in nine cases out of ten, pyloric or antral in situation and the stenosis is most frequently due to chronic, calloused, peptic ulcer. If, only *intermittently*, ten-hour retention is found, then spasm, (gastric, pyloric and duodenal) atony, ptosis, constipation or neurosis exists with or without non-stenosing, organic lesion.

Analysis of Retention Contents.—The average free HCl was 18. The average total acidity was 43. *Lactic acid* was present in less than 2 per cent. *Blood* by benzidin test was demonstrated in 22 per cent. Positive blood tests frequently resulted from food admixtures to the gastric extracts. *Fatty acids* were present in nearly 3 per cent. of stagnation extracts. (Heat test.)

Microscopic Examination.—Food rests of all kinds are common in gastric stagnation. Special search should be made for slightly altered, striated muscle fibers remaining from the meat given in the motor test-meal. Plant cells, remains of lettuce, celery or raisin skins, are usually identified without difficulty.

The chief characteristic of benign stagnation contents lies in the enormous number of actively budding *yeasts* and thickly grouped *sarcinæ* seen microscopically. Such indicate simple fermentative processes and are to be sharply differentiated from the bacteria-laden contents obtained from instances of malignant, pyloric stenosis In all the retention contents of our cases of benign pyloric stenosis budding yeasts were observed; in the stagnation cases the yeasts literally covered the microscopic field. In 76 per cent. of the stagnation gastric extracts sarcinæ (large or small type) were prominent. They usually lie in irregularly jumbled groups or form symmetrical, "cotton-bale" masses, often beautifully delimited. It was noted that the abundance of sarcinæ was in direct ratio to the degree of gastric atony and dilatation (Figs. 248 and 249).

(*b*) *Secretory Meal.*—Facts derived from the commonly used test-meal to determine gastric secretion are of comparatively little value in proving the existence of benign pyloric stenosis. This is especially the case if the stomach has been thoroughly cleaned by lavage before the secretory meal is given. By the Ewald or the Dock meals, the variations in gastric acidity are so great as to mean little or nothing diagnostically. In late stagnation, achylia may be encountered. In early stenosis, with peptic ulcer the cause, normal or increased free acid values may be obtained. The *quantity* of the removed test meal is generally greater than that recovered when the pylorus is freely patent. The amount removed by the tube is rarely less than 100 c.c. It often amounts to much more because of mucus admixtures or exuberantly secreting gastric mucosæ. These findings are not, however, characteristic for benign pyloric stenosis. They occur in other types of gastric ailment.

Roentgen Evidence of Benign Pyloric Stenosis.—*Motor Meal.*—A bulky, heavy meal composed of barium- or bismuth-impregnated mush finds difficulty in passing a narrowed pylorus within the arbitrarily established six-hour interval. This difficulty is especially aggravated in cases where a long maintained pyloric stenosis has resulted in fatigue and atony of the gastric musculature with subsequent dilatation of the stomach. In such event, practically all the metal-mixed, motor mush may remain in the stomach for days. Fluoroscopic examination or plates may readily prove such retention (Fig. 259).

Observation Meal.—When the stomach is filled with a bismuth or barium suspension, abnormalities in contour, size or position or fixation of the pyloric zone can often be shown at the fluorescopic examination. The stomach is generally enlarged. Peristalsis may be vigorous in recently established benign pyloric stenosis, but where the narrowing has existed for some time, peristalsis is weak or absent.

The *bulbus duodeni* may be poorly outlined, either as result of insufficient filling from the narrowed gastric exit or as a consequence of intra- or extraduodenal disease. The pylorus is sometimes of normal caliber, but the stenosis occurs in the first third of the duodenum itself. Fluoroscopy not infrequently permits the demonstration of the approximate

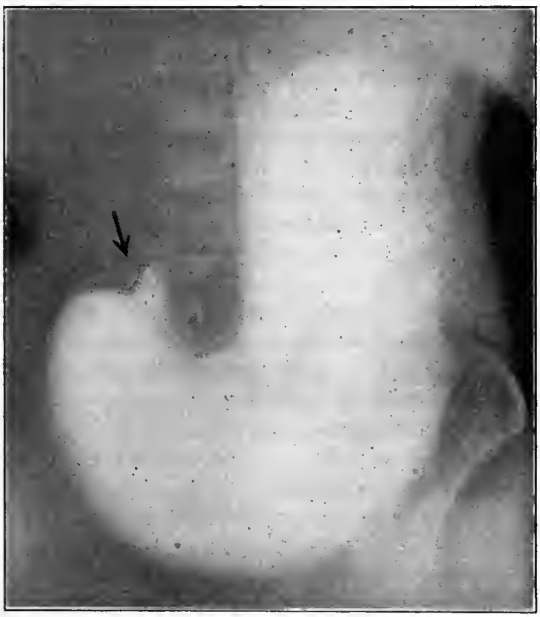


FIG. 259.—Pyloric stenosis caused by calloused, greater curvature, prepyloric ulcer (indicated by arrow). Note large, atonic stomach, the absence of peristalsis indicating muscle fatigue. (Original observation by author.)

location of the cause of the pyloric stenosis, particularly with respect to its gastric or extra-gastric situation. Prognostically, this information is often very valuable. It likewise assists surgeons in planning operative relief. Plates or films of the barium- or bismuth-filled stomach, furnish interesting visual records of the shape, size, position and contour of the altered stomach and the duodenum. They may demonstrate foreign bodies, gall-stones or cysts. Their limitations as complete records of the status of the case can only be appreciated upon comparison with the laparotomy, autopsy or pathologic studies.

THE RELATION BETWEEN GASTRIC ULCER AND GASTRIC CANCER.

Clinically the significance of gastric ulcer of the chronic type with respect to gastric cancer is still under discussion. The subject is of vast importance both as a diagnostic and a prognostic problem. To the surgeon the diagnostic value of detecting *ulcera carcinomatosa* lies in the knowledge that the extirpation of such defects yields the greatest proportion of malignant growths of the stomach that are operatively curable. Upon the internist rests the grave burden of segregating from the group of ulcer patients which appear for treatment, those amenable to non-surgical procedures from those in whom atypic cell changes exist and whose only hope of relief depends upon prompt, radical removal of the focus of disease. The problem is a difficult one.

While internists, with meager operating-room or laboratory experience, claim that a comparatively small number of chronic gastric ulcers ultimately undergo malignant transition, the admission that such ulcers do at times appear to be forerunners of cancers, indicates emphatically that, given an instance where calloused ulcer is proved to exist, the prospect of its being an *anlage* for a neoplasm must be admitted. In such event, the queer admixture of pride in personal opinion and mental bias dependent largely upon impressions gained from semi-ancient literature, which seemingly exists in some quarters, results in a professional attitude that is not in accord with modern facts and which is most pernicious with respect to the welfare of patients seeking aid.

There has been much old and recent controversy regarding the etiologic significance of gastric ulcer and gastric cancer. In 1882, Zenker stated that, in his belief, all gastric cancers originated from previous ulcers. Seven years later, Rosenheim supported Zenker's opinion. In 1902, Fütterer, after extensive experimental studies, summarized his results by the observation that gastric cancer develops with great frequency from ulcer located in the pyloric fourth of the stomach, but that malignant transition is less common when the ulcer is situated in other parts of the viscus. Fenwick, from an apparently limited operating-room and pathologic experience, claims that but 3 per cent. of ulcers become cancerous. Friedenwald, after a study of one thousand cases, clinically gastric cancer (but 26.6 per cent. came to laparotomy or autopsy), places the frequency of cancer's arising upon previous ulcer at 7.3 per cent. Moynihan claims that fully 66 per cent. of his cases of gastric cancer had previously been affected with chronic gastric ulcer. Sapeska, after a careful review of 100 cases of gastric cancer, could find but 10 instances where previously calloused ulcer had apparently not existed.

The wide diversity of opinion shown by the above observations needs explanation. There has been a confusion of viewpoint, partly, because certain clinicians attempt to establish facts from pathologically unproved diagnoses and, partly, because from the statement that, for example, more than 60 per cent. of gastric cancers apparently exhib-

ited a previous history of chronic ulcer, it is loosely assumed that the reverse is true: namely, that fully as large a percentage of benign gastric ulcers undergo malignant change. In order to properly comprehend the difficulties associated with determining the interrelation between peptic ulcer and cancer of the stomach, it is quite necessary to understand the nature of both gastric ulcer and gastric cancer. As an aid to interpreting some of the aspects of the problem, the writer analyzed 921 gastric cancers and 500 benign gastric ulcers. The diagnoses in all instances were operatively and pathologically established.

1. The Nature of Gastric Ulcer.—(*a*) *Origin.*—All types of benign gastric ulcer may be produced experimentally by a wide variety of methods. Bolton classifies some of the more familiar causative agents as (1) *bacteria* (pneumococci by Dieulafoy, staphylococci by Widal and Meslay, staphylococcus aureus by Letulle, bacillus pyocyaneus by Charrin and Ruffer, bacillus dysenterii by Chantemesse and Widal, lactic acid bacillus by Wurtz and Leudet, bacillus of Pfeiffer by Statineano, meningococcus by Weichselbaum and by Gaudy and Griffon, Eberth's bacillus and bacillus coli by Rodet and Zaidmann, streptococcus by Rosenow); (2) *bacterial toxins* (pyemias by Lebert and by Cohn, diphtheria toxin by Enriguez and Hallion, and Rosenau and Anderson); (3) *cutaneous burns* (Welty, Ponfick, Silbermann, Parascandolo); (4) *poisons of metabolic origin* (Bolton's "gastrotoxin" injected intraperitoneally or subcutaneously); (5) *extrinsic poisons* (mercury salts, arsenious acid, cantharidine, vegetable alkaloids, pilocarpine, atropine, copper sulphate); (6) *poisons introduced into the stomach* (corrosives and caustics) and (7) *alterations in the stomach's circulation* (vascular blocking, thrombi, emboli, arteriosclerosis, nervous inhibition, or external pressure). The type of ulcer produced experimentally, varies slightly according to the method employed in causing it. The resultant lesions are, however, essentially similar. There is loss of surface epithelium, necrosis, inflammatory edema, hemorrhage and glandular destruction. In the healing of ulcers, irrespective of the way they may have been produced, the essential feature consists in development of new epithelium, protective connective-tissue by hyperplasia, with resultant scar.

(*b*) *Course.*—In neither experimental animals nor the human can the life history of any gastric ulcer be prognosed. This applies with respect both the extent of the lesion and the amount of tissue destruction taking place. That most gastric ulcers have a natural tendency to heal is shown by the rapid appearance of scar formation in experimental animals, the discovery of healed ulcers at laparotomy or necropsy, and the clinical "cure" of ulcers by widely varying modes of medical or surgical treatment. The time required for ulcer formation or the healing of such seems to have wide limits. There are factors concerned which appear to be largely individual. Certainly, chronicity of an ulcer, pathologically, does not necessarily coincide with chronicity in the sense of duration in terms of months or years. Huge, excavated calloused ulcers may form in a few weeks while superficial, bleeding

erosions or small calloused ulcers may exist for years with no evident extension or marked connective-tissue hyperplasia.

(*c*) *Malignant Change.*—That some element other than the persistent presence of an ulcer in a functionating stomach is necessary as the forerunner to the transformation of a benign process to a malignant one is indicated by the fact that no experimenter has ever produced, in animal or man, a cancerous ulcer. Chronic irritation, infection, artificial anemia, starvation, overfeeding or local application of chemicals have all failed to cause such histologic picture as seen in *ulcus carcinomatosum, i. e.,* the power of atypic, unlimited cell growth with ability to cause death of the host by malignant intoxication and metastases. Just how such change occurs in man we are not able to state. Herein lies one of the strong points of argument for those clinicians and pathologists who claim that benign gastric ulcer rarely becomes malignant. No one has ever seen the actual transition from a benign process to cancer. In a given specimen examined microscopically, one can only say that *cancer is or is not* present. Atypic hyperplasias may render a diagnosis of early malignancy highly probable by one experienced in the examination of fresh tissue, but it appears impossible to definitely state that an ulcer which shows cancerous changes in a few spots of its edge was ever anything else than malignant. Certainly, one cannot say unqualifiedly, that the part of the mucosa that has sloughed away was benign. Such part may have been cancerous and have been prevented from wider incursions into the gastric wall by the very atypic hyperplasia, so-called, that remains for our study. What we see, may be an indication of a histologic battle, already a partial victory. The subsequent spread of the few malignant rests which are present, may follow as a consequence of exhaustion of the protective mechanism through the first attempt at defence. When an ulcer is excised at laparotomy the histologic contest is interrupted. One cannot satisfactorily prognose what the ultimate outcome would have been had the conflict been allowed to proceed. It is only when one observes cancerous ulceration, with evidences of perigastric, lymph-gland invasion, that it is possible to state that the disease will progress to the death of the host.

(*d*) *Frequency of the Transition of Benign Gastric Ulcer to Cancer.*—There has been much misunderstanding in this regard. Publication of reports, claiming that the clinical type of dyspepsia which frequently precedes what is commonly recognized as a malignant form of gastric disease, is often not to be differentiated from chronic peptic ulcer, has given rise to a widespread impression that large numbers of chronic gastric ulcers terminate as cancers. Clinical experience and pathologic facts are far from lending support to this conclusion. While the writer's study of the early histories of 921 instances of proved gastric cancer indicates that more than 65 per cent. of the cases had a long dyspeptic course (apparently of benign type), preceding that which clinically, was malignant, it does not establish the fact that a like proportion of benign gastric ulcers eventually termi-

nate as cancers. Granted, that the so-called precarcinomatous manifestations of gastric cancer closely simulate those of benign peptic ulcer, it is not unlikely that the common conception, clinically, of the symptomatology of ulcer and of cancer of the stomach is an imperfect one. As there is, histologically, a group of ulcers in which sections do not permit of accurate differentiation between benignity and malignancy, it is not improbable that there are stages in both gastric ulcer and cancer where clinical recognition of each ailment is impossible. Our conception of how ulcer and cancer of the stomach make themselves manifest clinically, may be too narrow.

Pathologically, the strongest proof that exists of the frequency of the histologic transition of benign ulcer to malignant ulcer is advanced by MacCarty. From a most complete and painstaking study he has demonstrated that of 280 resected, chronic, calloused gastric ulcers, in which there was no clinical or gross surgical hint of malignancy, 63 per cent. showed evidences of atypic or undifferentiated cell-groups in their hyperplastic edges. This is an important array of facts and has highly suggestive application, clinically, but etiologically, as MacCarty frankly admits, it carries no proof that those ulcers showing atypic cell arrangement and structure were ever benign, histologically. While the length of the period of dyspepsia associated with the demonstration of these ulcers might, clinically, indicate a previously benign process, it does not prove that such actually existed. Our conception of the time of possible duration of malignancy may require readjustment. On purely empiric grounds, the clinical picture of gastric cancer has become firmly established as one of a perniciously and progressively downward process, with fatal termination within from one to three years. How long malignancy can exist in a stomach before evidences are clinically present, we do not know. The disease may lie "latent" for many years before local or constitutional changes become apparent. More than 1.5 per cent. of the writer's cases of well-advanced gastric cancer gave rise to no symptoms directly pointing to a gastric upset. The knowledge that gastric ulcers may exist without producing so-called "ulcer dyspepsia," is proved by the not infrequent finding of calloused gastric ulcers at laparotomy for other ailments, or at necropsy. It is thus evident, that it is frequently impossible to judge the histology of gastric mucosa, from clinical manifestations alone, previous to the time when clinical proof indicates that cancer has developed: foundation for the neoplasm may have long been present, either as ulcer or as some yet unknown cellular malarrangement or intracellular metabolic fault.

The writer's study of 500 surgically demonstrated cases of benign gastric ulcer in no way indicates the frequency of cancer formation from such. That this is to be expected is emphasized by the fact that our cases are all classified upon a pathological basis, *i. e.*, a specimen is either benign ulcer, undetermined ulcer histologically or gastric cancer, with or without the association of ulceration. Presuming that our 500 cases of benign gastric ulcer form part of a numerous group

which appeared at some time previously, it is manifestly impossible to tell what course the original ulcer group has taken—namely, how many have healed spontaneously or with the aid of medical care, how many have survived as benign ulcer cases, on how many have surgical procedures been performed, and how many have terminated as cancers. In the writer's opinion the above facts furnish insurmountable obstacles to the possibility of any, even approximately correct, estimate being made with regard to the frequency with which benign gastric ulcer becomes malignant. Whatever may be individual opinion or clinical experience, it would seem that this phase of the subject remains unsettled.

(*e*) *Clinical Variations in the Symptom-complex of Gastric Ulcer.*—That a difference of opinion exists among clinicians with regard to what set of symptoms and signs actually indicate peptic ulcer is readily noted upon the perusal of the opinions of those men who have had experience with any considerable material. Symptom-complexes, based solely upon individual interpretation of a group of complaints, signs or tests, cannot expect unqualified acceptance. However, when certain clinical pictures of disease are found in association with the pathologic proof that such disease exists, symptom-complexes can be rationally formulated,—and only when measured by this rule are these above criticism. The close simulation of the symptomatology of uncomplicated gastric ulcer by disease of other abdominal organs (gall-bladder, appendix, colon, etc.) would appear to suggest that the clinical manifestations often associated with ulcer are often the evidences of an abdominal or a constitutional disarrangement, in the course of which gastric ulceration is an incident or an end-result. Certain support to this conception of the disease is furnished by the experimental production of gastric ulcers by many and widely different methods and agents. It is within the experience of all who have had a liberal training, that not infrequently laparotomy or necropsy, at the most competent hands, fails to demonstrate ulceration in patients presenting so-called characteristic clinical manifestations of the ailment. Conversely, it is equally surprising to discover well-advanced gastric ulcer which has produced no symptoms referable to the stomach, at laparotomy for extra-gastric disease or at necropsy following deaths due to accident or extra-abdominal affections. From the foregoing, it would appear likely that the symptomatology which is commonly associated with gastric ulcer, clinically, is the manifestation of a group of derangements among which ulcer of the stomach is included. The above would appear to impose another limitation to the accuracy with which it is possible to determine the relationship between gastric ulcer and gastric cancer. It is not beyond probability that much evidence which has been adduced from merely clinical symptomatology determining diagnoses is not admissible, inasmuch as in many instances peptic ulcers were not present.

(*f*) *Malignant Change in Duodenal Ulcer.*—In a consecutive series, the writer's 500 operatively demonstrated instances of gastric ulcer

were found to exist in 1725 cases of peptic ulcer, gastric and duodenal. It is thus seen that the ratio existing between the frequency of gastric and of duodenal ulcer is as 1 : 2.45. While duodenal ulcer is much more frequent than is gastric ulcer, cancer of the duodenum is very uncommon. From a careful perusal of records, the writer noted it seven times. It has been advanced, that, if gastric ulcer frequently undergoes malignant transition, then one should expect a high ratio of malignant duodenal ulcers.

When primary cancer of the duodenum is found, it is usually located at or near the papilla of Vater. In such situations, the viscus is liable to injury from gall-stones, altered secretions of the liver and the pancreas, and infective processes from the gall-tract. Moreover, at the papilla of Vater, there may be stagnation of duodenal contents or slowing of the rate of discharge of the digestive juices from the liver and the pancreas. It should be also emphasized that ordinarily, there is little opportunity for traumata to the duodenal mucosa from retarded food progression. Food remains for a very brief time in the duodenum, provided stenoses do not exist. The opposite condition exists in the stomach, in which event, there is abundant time for bacterial, chemical or mechanical injury to a gastric lining already robbed of some of its resistance. That the duodenum appears to have an inherent protective mechanism against malignancy appears to be demonstrated by the observation that only rarely does cancer of the stomach greatly involve the duodenum by direct extension. The different character of the tissue of this part of the gut seems to be indicated by the fact that, not infrequently, duodenal ulcers, which have extended to the pylorus, assume malignant characteristics in their stomach edges and nowhere else.

(*g*) *Gastro-enterostomy as a Protection Against Malignant Transition of Gastric Ulcer.*—Given a gastric ulcer, proved to exist by laparotomy, if such ulcer be not excised, it appears to have been shown by competent observers that after gastro-enterostomy malignancy rarely supervenes. In our series, there were nine patients, with apparently benign gastric ulcers, who appeared with cancers of the stomach after anterior or posterior gastro-enterostomy had been performed. Of course, inasmuch as none of these ulcers had been microscopically examined before gastro-enterostomy, it is not possible to state that such were not malignant at the time that the operations were performed.

It should be recalled that modern surgeons do not consider gastro-enterostomy as an operation solely of "drainage." It is well recognized, that after such surgical procedure, the physiology of the stomach has been altered in many particulars: not rarely, the stomach's emptying power is accelerated and thus stagnant food, often very foul bacteriologically, remains for a shorter time in contact with a damaged mucosa; blood and lymph circulations may be appreciably changed as a consequence of relief from dilatation of the stomach and alterations in the peristaltic rhythm; in nearly 85 per cent. of gastric extracts of cases where gastro-enterostomy has been done, the writer demon-

strated, by chemical or microscopic means, both duodenal and jejunal contents—material from parts of the gut relatively immune to malignant disease, and finally, after gastro-enterostomy, he was able to demonstrate in a series of 121 consecutive instances of gastric ulcer, an average decrease of 17 free hydrochloric acid, together with appreciable diminution in peptolysis. Clinically, it is the general experience that in malignant disease of the stomach, not associated with stenosis, gastro-enterostomy appears to grant a longer lease of life than where such has not been performed.

II. **The Nature of Gastric Cancer.** — (*a*) *Origin.* — No one has ever seen the actual beginnings, histologically, of malignant disease of the stomach. While experiments in tumor transmission, by Rous and Murphy, reveal certain tissue-reactions to the presence of artificially introduced foreign cells, it cannot be said that such reactions are entirely comparable to those occurring when a tumor arises spontaneously from native tissue. MacCarty has apparently shown that malignancy begins as a form of hyperplasia of already existing cell-structures. This hyperplasia results in functionally undifferentiated, and architecturally imperfect, primary cell elements. This hyperplasia varies in degree, and at certain stages cannot be segregated, histologically, from the forms of hyperplasia common in processes of so-called benign nature. Apparently, in certain of these grades of hyperplasia, the line of demarcation between the malignant and the benign is, with our present methods of examination, extremely indefinite. In the case of gastric cancer, however, once this "halting stage" is passed, the histologic picture is well defined and the disease progresses rapidly. Evidence strongly supporting the pathologic proof that malignancy may develop in gastric ulcers that were apparently benign, is furnished by the histological observation of all degrees of hyperplasia—benign, indeterminate and malignant—in sections through different portions of a given excised ulcer.

(*b*) *Course.*—Unless total extirpation is possible, gastric cancer produces death of its host. Unlimited growth, with the property of developing metastases in near or distant organs, rapidly results in fatal malignant intoxication, hemorrhage, starvation or exhaustion. Rarely do proved instances of gastric cancer live longer than three years. Unless there is early surgical interference, the majority of hosts die within a year following the onset of symptoms. In the writer's cases of cancer of the stomach, the average duration of all symptoms, of a clinically malignant type, was 6.9 months previous to the patients' coming for relief. There are wide variations in the rate of progress of the disease. The same type of ailment, histologically, progresses with strikingly different speeds in different individuals. The factors concerned in the ability of gastric mucosa to resist cancer invasion are not as yet understood. One individual may be overwhelmed with the disease in a few weeks while another may successfully resist the affection for several years.

The above observations offer suggestions respecting the possibilities

for variability in the symptom-complex of gastric cancer. Our records show that more than 1.5 per cent. of operatively demonstrated instances of the disease, gave no pre-laparotomy manifestations that pointed to an ailment of the stomach. Clinically, however, the major portion of the cases fall into two great groups, with respect to course: (1) *Instances where a chronic dyspeptic disturbance, clinically benign in character, was followed by an ailment of the stomach, which, from its inception, appeared clinically malignant,* and (2) *instances where a continuous and progressively downward gastric disease, clinically malignant, arose in individuals who had had no previous digestive faults.*

Group I.—There were 520 cases (56.4 per cent.) comprising this class. In 436 instances (47.3 per cent.) the portion of the history preceding the apparently carcinomatous phase was, *clinically,* that which is commonly accepted as indicating benign gastric ulcer. In 84 cases (9.12 per cent.) the dyspepsia previous to the onset of clinical malignancy, was *clinically* of benign type, and of the character which is commonly associated, clinically, with irregular gastric ulcer. The average duration of all symptoms in the apparently benign portion of the history was 11.2 years for both divisions. The average duration of all symptoms which *clinically* indicated the duration of a *malignant* disease was nearly six months.

On account of the variability in a clinical complex indicating absolutely the presence of gastric ulcer, the above figures do not actually prove that peptic ulcer had existed before the beginning of a gastric disease which was later shown to be cancer. However, it is significant, to recall that, clinically, the segregation of the cases, making up this group, conforms to the accepted clinical complex of gastric ulcer, and that in large series of cases when patients presenting such symptoms are operated upon, chronic gastric ulcers are found. Moreover, on further analysis of the laparotomy findings, in cases making up this group, above defined, a disease process, still localized and frequently presenting the macroscopic characteristics of chronic indurated ulcer was demonstrated. Cancerous ulcers were found in nearly 42 per cent. of instances, and with such was associated the minimum of perigastric lymph-gland invasion. Finally, certain interesting, and perhaps suggestive, facts may be adduced from note of the incidence of hemorrhage in our series of gastric cancer. There were 151 instances where, during the course of the entire ailment, gross hemorrhage had occurred (16.4 per cent.). Of the whole number bleeding, 93 cases (62 per cent.) were included in the group where dyspepsia of the ulcer type, *clinically,* had preceded that evidently cancerous. Of the whole number with history of melena or hematemesis, 77 cases (51 per cent.) had bled at least two years previous to their coming under observation. Of the instances having hemorrhage within two years of coming under observation, 55 cases (76 per cent.) gave histories classifying them into the ulcer-dyspepsia group, *clinically,* preceding clinical cancer.

From the above it is apparent that in the large majority of gastric cancers, there is a previous long-term history of a type which it is

impossible to separate *clinically* from benign, gastric ulcer dyspepsia; that the minority of gastric cancers arise in the stomachs of individuals who have previously had no gastric upsets, and that recognition of these facts permits laparotomy at a stage of the disease when the maximum advantage, surgically, can be taken of a localized process, with a corresponding high proportion of cures.

GROUP II.—In this class—that forming the group commonly considered, *clinically*, gastric cancer—there were 294 cases (31.9 per cent.). The average duration of all symptoms of stomach malfunction was 7.2 months. Careful questioning failed to elicit dyspepsia of any clinical variety, previous to the inception of that which was clinically malignant. This observation does not prove that such individuals had had no gastric pathology prior to their appearing with cancer. While, clinically, it is considered relatively uncommon for ulcer or cancer to exist without the production of digestive upset, yet, as we have already mentioned, such a condition is not absolutely impossible. That gastric ulcer had not existed in this group for any considerable period previous to the onset of cancer, appears probable when we recall that nearly 4 of every 5 instances of surgically proved cases of ulcer are associated with fairly definite signs and symptoms. That gastric cancer had lain "latent" for a considerable time before giving rise to clinical manifestations is of course possible, but in view of our knowledge of malignant processes in other body tissues, scarcely probable. Inasmuch as we have very little definite information with regard to the rate of growth either of gastric ulcer or cancer in terms of weeks, months or years, it is not possible to state that the whole gamut of initial trauma to the gastric lining, ulceration and malignant change was not (in cases of this group) run through in relatively short time. In this group of patients at laparotomy cancerous ulcers were demonstrated in but 56 (19 per cent.). These may have resulted from ulcers previously benign, from necrosis and sloughing of primary cancers, or the malignancy may have arisen primarily in ulcer form. From our present histologic knowledge there is nothing revealed upon the examination of these neoplasms that indicates the nature of the initial process.

(*c*) *Position in the Stomach Wall of Gastric Ulcers and Gastric Cancers.*—In 37 per cent. of the writer's cases of cancer, the tumor was located at the pylorus; in 28.2 per cent. on the lesser curvature or in the antrum; in 18.3 per cent. it was general; in 6.8 per cent. on the posterior wall; in 5 per cent. at the cardia; in 1.3 per cent. on the greater curvature; in 0.65 per cent. at the fundus and in 0.5 per cent. on the anterior wall. In approximately 3 per cent. of instances the location of the growth was not definitely described.

The above figures are to be contrasted with those given for the situation of gastric cancers by observers who have studied mainly post-mortem material (Welch, Brinton, Lebert and others). To anyone who has examined the *end-results* of gastric cancer at necropsy, it is not necessary to state that at such times precise evidence of the point of origin of the disease is not available. Figures for the situation of

gastric cancers have been returned from the laparotomy examinations. They are suggestive when it is observed that they approximate closely the figures given by Welch and the writer for the location of chronic, indurated gastric ulcer. From the etiologic point of view, there may be more than a coincidence between the similarity of situation of gastric cancer and of gastric ulcer in living patients.

SYPHILIS OF THE STOMACH.

Anatomic changes due to lues in the stomach wall are by no means so rare as formerly considered. During the past five years more instances of gastric syphilis have been placed on record than are contained in the literature for the three previous decades. This recently discovered prevalence of the ailment is largely a result of the more general use of serologic tests in differential diagnosis of intra-abdominal disease and of roentgen examinations.

Incidence.—Recent studies by the writer and by other observers indicate an approximate frequency of gastric lues, of one in 330 gastric cases (.42 per cent.). Of 8341 patients analyzed, there were 1760 instances in which the gastric upset was associated apparently with demonstrable pathology in the stomach or duodenum. Of these 2 per cent. were luetic. The relative incidence of the syphilitic affection is emphasized by noting that in this group of cases, gastric cancer was found in 17 per cent., gastric ulcer in 18.2 per cent., duodenal ulcer in 41 per cent., achylias or chronic gastritis in 23.4 per cent.

Etiology.—*Sex.*—In the author's series, there were of 35 cases, 22 men and 13 women.

Age.—The minimum age was nineteen years; the maximum sixty-six. The minimum age for men was nineteen; for women twenty-six. The maximum age for men was sixty; for women sixty-six. The accompanying table indicates the age incidence by decades for the sexes:

TABLE SHOWING AGE AND SEX INCIDENCE OF GASTRIC SYPHILIS.

Years.	Number of men.	Number of women.
0 to 10	0	0
10 to 20	1	0
20 to 30	3	4
30 to 40	5	2
40 to 50	5	3
50 to 60	6	3
60 to 70	2	1
Total	22	13

It was noted that the average for women was 40.8 years and that for men 41.3 years, a sex difference of .5 years.

Pathology.—The lesion may be congenital or acquired. It is doubtless always part of a general systemic syphilis but the luetic lesion may be grossly manifested locally only in the stomach. The infrequency of the affection in general syphilis is shown by the statistics of Chiari.

From necropsies in 243 pathologically demonstrated cases of lues, of which in 145 cases the disease was hereditary and 98 cases it was acquired, he noted that, while *indirect* changes in the stomach wall (circulatory anomalies, interstitial hemorrhages, toughness of the tissues, etc.) are relatively common, lesions *directly attributable* to lues (ulceration, gummas and scarring) were infrequent.

Careful descriptions of luetic lesions in the stomach have been made by Flexner, Neumann, and by Chiari and Weichselbaum, while clinical classifications relating thereto have been advanced by Hemmeter, Einhorn, Kohn, Morgan, Downes and LeWald, McNeil and by Eusterman. It would seem from the nature of the ailment pathologically, that a close histoclinical grouping were possible.

Recent observations of Warthin at the Pathological Laboratory of the University of Michigan promise to throw an interesting and valuable light upon the prevalence of syphilitic lesions in the gastro-intestinal tract. Warthin has definitely demonstrated the existence of histopathological changes in the pancreas similar in every respect to those existing in chronic syphilitic foci in heart-muscle, aorta, etc. In many of Warthin's specimens, careful staining by the Levaditi method reveals spirochetæ. It is more than likely that similar studies made upon sections of extirpated gastric walls, from patients with lues presenting dyspeptic abnormalities, will disclose lesions very similar to those that Warthin has shown in the pancreas.

These definite pathologic observations should be of great value clinically. They should lead to earlier thought of the possibility of syphilis producing numerous types of gastric upset and should more frequently suggest anti-luetic therapy in cases which have resisted ordinary routine treatment.

Apparently activity of the syphilitic virus first causes a dense round-cell infiltration of the loose, areolar tissue of the stomach wall. There is frequently an associated endarteritis. When the disease has once become firmly established, it appears to produce four rather characteristic types of lesion: (1) Diffuse infiltrations, confined to the areolar tissue, causing thickening and stiffening of the gastric wall ("cirrhosis gastrica"); (2) local changes in submucosa and mucosa in the form of dense groupings of lymphocytes, which may end as miliary gummas, or coalesce, necrose and slough forming ragged-edged ulcers, not infrequently multiple; (3) single or multiple inflammatory nodules, composed of exuberant connective tissue and lymphocytes; these may involve the entire stomach wall and produce extensive tumors (ulcerating or non-ulcerating), stenoses or malformations in contour, and (4) subperitoneal and peritoneal invasions, resulting in perigastritis associated with thickening of the wall of the viscus and dense perigastric adhesions. Doubtless by proper manipulation of the Levaditi technic, spirochetæ will ultimately be demonstrated in all the types of lesion above described.

As a consequence of these pathological variations, the clinical manifestations of the malady differ widely. Grossly, they may be sum-

marized as those associated with chronic gastritis, ulceration (with or without stenosis), gastric tumor (with or without obstruction) and perigastritis, sometimes with involvement of adjacent viscera.

The Luetic Lesion.—It was often difficult to get a history of the primary sore. This is particularly apt to be the case with women. Of the men, genital chancres were recorded in 9, buboes in 4, mouth or lip lesions in 2. In the women genital chancre was reported three times. In 2 cases there had been mouth sores; in 1, buboes. Definite knowledge of veneral disease in the husband was obtained in 5 instances; in 2, the husband's condition was questionable. Of the entire group, there were 9 cases in which no history positive for or suggestive of lues could be obtained, nor in these patients could external evidences of previous lesions be seen. The Wassermann-Noguchi tests were, however, definitely positive.

Time of Gastric Disturbance After Acquirement of Lues.—Information in this line is but relatively correct, especially for the women. The average shows that there was but slight variation in the sexes. Two years was the minimum quiescent period for both sexes, while the maximum, was, for men, thirty-eight years and for women, forty-five years.

Stage of the Disease.—So far as we were able to judge, we had no instance of a congenital affection. In three males and two females, the ailment appeared late in the secondary stage of lues. In the remaining cases (30) the gastric disorder was, etiologically considered, a tertiary manifestation.

Previous Specific Therapy.—Of the 21 cases who gave definite or suspicious history of chancres or of buboes, but 11 had had anti-luetic treatment. Of these only 5 had received a thorough course of mercury and iodid. Four had been given salvarsan for "anemia" within five years of their coming under observation.

Wassermann-Noguchi Reactions.—These were positive in all our tabulated cases and furnish the basis of our classification. Inasmuch as the nature of the ailment demands diagnosis apart from surgical or from sections of tissue removed at laparotomy or necropsy, we fail to see how another basis for classification can be adopted. Certainly, dependence solely on the "therapeutic test" of the effect of antiluetic medicines is not sufficient proof of the disease, for it has been shown that occasionally sarcomas, tuberculous lesions or other inflammatory affections are favorably influenced by salvarsan, mercury or iodids. If carefully controlled, only rarely is the positive serologic test associated with disease other than syphilis. In grave anemias, malignant cachexia or alcoholism, dubious Wassermann reactions are occasionally obtained. However, such factors were ruled out in our group of cases.

The Gastric Malfunction.—*Duration of All Gastric Disturbances.*—Facts of considerable significance are brought out by analyses of this phase. It has been stated frequently that gastric syphilis manifests itself rather abruptly in late life without any previous digestive upset having been noted. Other observers have suggested that the ailment

causes great cellular damage to the stomach wall early in life. Our study indicates that the average duration of dyspepsia was 7.2 years for the group. The minimum duration was six months—a male aged sixty; the maximum, twenty-five years—a female aged fifty-two years. There was practically no difference in the average duration between the sexes.

Duration of the Presenting Gastric Complaint.—The average time for the group was 9.7 months. The minimum was four weeks and the maximum 4.2 years. In women, dyspepsia caused the patient to seek relief rather earlier than in men.

Types of Gastric Histories.—The wide variations in the pathology of syphilis of the stomach indicate that a great range is possible in the clinical picture presented. In the literature too much emphasis has been placed upon gastric syphilis at its tumor stage ("surgical syphilis"). It will be recalled that, histopathologically, gummatous formation indicates an approach to the terminal damage which the syphilitic virus is capable of producing. It is quite evident that the maximum worth of medical treatment of this affection is possible only before gross deformity of the stomach wall and loss of secretory function have occurred.

The writer's cases group themselves quite readily, with regard to the clinical course of the dyspepsia, into *three divisions:* (1) Instances in which a persistent gastric derangement appeared in the individuals who had previously experienced no digestive upset; (2) instances in which a constant dyspepsia followed years of antecedent indigestion of the intermittent type; (3) instances in which continuous gastric upset arose in persons who had been affected gastrically at some past period, but who had been, for years, free from digestive disturbances.

In luetics it is often difficult to ascribe gastric upsets to definite pathological change in the stomach wall unless the dyspeptic disturbance has preceded evidences of cerebrospinal damage. The roentgen demonstration of gastric deformity is of much service in the doubtful cases. Each group will be summarized briefly.

Group 1.—Three of the thirty-five instances of gastric syphilis studied composed this group. All were men who gave histories of genital, primary lesions. In one, the dyspepsia appeared shortly after secondary skin lesions had subsided, in the others it was the only evidence of the tertiary stage. The affection was characterized by rather abrupt onset of epigastric pain and soreness, constant in character, but varying in intensity; by anorexia, moderate weight loss, constipation, pyrosis, eructations, epigastric tenderness, and in one instance a freely movable, epigastric nodule and with "delayed vomiting." Gastric analyses revealed a fairly low formol index, absent Wolff test and moderate hypersecretion, without hyperacidity. In the case associated with epigastric nodule, fluoroscopic examination showed a filling-defect involving the pylorus and the antrum. In the other patients, roentgenoscopy pointed to pyloric ulcers of the chronic, uncomplicated variety.

GROUP 2.—This division contained 12 cases (34 per cent.). The histories exhibit two rather strikingly different phases of disease: (*a*) An early dyspepsia, characterized by frequent attacks of discomfort which has the clinical aspect of recurrent peptic ulcer and (*b*) a subsequent period of continuous dyspepsia, which frequently presents an aspect different from that exhibited by the first portion of the ailment.

The average duration of all symptoms in the *first phase* of the disease was 8.3 years. It varied between seventeen months and twenty-three years. The histories indicate a gastric derangement associated with periodic attacks of epigastric distress ("burning," "gnawing," "sore," "ache" or "colics") not uncommonly more pronounced at night or when the stomach was empty, irregular vomiting (hematemesis in two instances), water-brash, good appetite and body nourishment and with abdominal tenderness. In the intervals between attacks, even without treatment, the patients were usually comfortable. So closely do symptoms and signs simulate those of non-luetic recurrent gastric ulcer, that the clinical differentiation, without the knowledge of specific infection or positive serologic test, is quite impossible. Five patients in this group had taken so-called ulcer "cures" repeatedly and five others had submitted to surgical exploration: in three of these, ulcers of the stomach had been found and posterior gastro-enterostomies performed.

The average duration of all symptoms in the *second phase* of this group was 1.3 years. The shortest period of discomfort was seven weeks; the longest nearly three years. This phase of the ailment was different from that preceding it, in that the patients were *constantly* annoyed by epigastric distress, frequently aggravated at night and sufficiently severe to require opiates (50 per cent.). During this stage, weight loss was not uncommonly rapid and of marked degree. The average weight loss in the three months preceding the time that the patients appeared for examination was 16.2 pounds. There was one case in which weight loss was mentioned as "slight." The least weight loss was 5 pounds, the greatest 47.

Epigastric pain and tenderness were generally most marked in the right upper quadrant. In six instances (50 per cent.) there was a palpable epigastric mass. Pain was most commonly relieved by limiting the amount of ingested food, by lavage and the taking of alkalies. In four instances persistent vomiting developed, with coincident evidences of marked gastric stagnation.

Test-meals revealed an average total acidity of 34.6, and average free hydrochloric acid 27. In only two instances was hydrochloric acid absent. The highest free hydrochloric acid noted was 110. Twelve-hour retention was demonstrated in four cases. In eight instances in which the formol index was estimated, it averaged 9.6. In three instances, the Wolff test for soluble albumin was positive, but it was negative in six. Lactic acid was observed twice. In the cases in which hydrochloric acid was absent, organisms simulating those of the Oppler-Boas group were recorded.

Roentgenoscopy returned the diagnosis of chronic peptic ulcer or "suspicious" ulcer or "tumor" of the stomach in nine instances. In only one case had the question of syphilis been considered. In seven patients exploratory laparotomy was performed. In four instances, smooth, pale, calloused ulcers were noted (in one case three ulcers were noted on the anterior wall and one on the lesser curvature). The stomachs of two patients exhibited diffuse, infiltrating, scirrhus growths, and in one, a small nodule on the lesser curvature. In the remaining cases, smooth, hard tumors involved the pyloric portion of the stomach.

From the above summary of cases making up Group 2, it is seen that the clinical course strongly simulates that of chronic peptic ulcer which later undergoes malignant degeneration—with this exception, however, that while anemia, weight loss, pyloric obstruction, cachexia and epigastric nodule or ridge may be present, the gastric analysis reveals moderately high total and free hydrochloric acid with no increase above the normal formol index, and with only irregular manifestations of a positive Wolff test. Some stomachs exhibit very rapid emptying. This is not due to vigorous peristalsis, but seemingly to the stiff, thick, gastric walls permitting food (especially opaque, roentgen meals) to "drop' into the jejenum as does water through a funnel. At laparotomy, the diagnosis is often in doubt, but surgeons of experience have learned to leave undisturbed the well-delimited, hard, plaque-like ulcers and the firm nodular tumors which arise from a stomach wall, already thickened by diffuse, infiltrating, exuberant connective tissue. It is in this class of case that information of vital value is received from the serologic test. The reaction frequently determines the advisability of surgical interference.

Group 3.—Twenty cases composed this division. The early portion of the histories in these instances is not characteristic of any definite clinical type of intragastric disease, associated with any special, gross, anatomic lesion. Previous to the terminal complaint, the early gastric upset has made itself manifest in "spells" often at long or irregular intervals. Not uncommonly, the different attacks exhibit no similarity as to type. In this group, the average duration of the early gastric dyspepsia was 10.2 years. The shortest period was seven months; the longest twenty-eight.

In the first stage, the indigestion was variously associated with epigastric discomfort (often styled "vague ache" with tightness and burning), and frequently complicated by irregular, colicky attacks. Cord changes were not observed. The pain was usually situated in the "pit" of the stomach, or the right epigastrium, but not rarely had no definite point of localization. Pain relief was commonly obtained by diet, alkalies, vomiting, the ingestion of food or the administration of an opiate. In but five instances did the epigastric distress bear any constant relation to food intake. This type of gastric malfunction eventually terminated in a stage in which the dyspepsia was *constant*. There then ensued loss of appetite, constipation or constipation alternating with diarrhea, and

weight decline averaging, for the group, 19.6 pounds. In six instances there were epigastric ridges or masses; in two cases these were complicated by pyloric obstruction.

The test-meals revealed an average total acidity of 46.2 and average free hydrochloric acid of 28. There were only three instances in which hydrochloric acid was absent. In eleven instances in which the formol index was estimated, it averaged 9.7. In the same group the Wolff test was positive four times. Roentgen records of an intragastric condition simulating chronic ulcer or tumor were obtained in eleven cases. In the remaining instances, the examination was not made or its results were questionable. Surgical exploration was performed in ten cases. Laparotomy disclosed chronic ulcer or single or multiple fibrous nodules. In one case, the stomach appeared thickened, the mucosa was congested and velvety but was otherwise negative. The gall-bladder was filled with stones.

The above description of cases making up Group 3 demonstrates that although the early part of the history may differ markedly from that composing the first portion of that outlined in Group 2, the terminal stage and the laparotomy findings are strikingly similar to it.

Laboratory Data.—*Blood.*—In seventeen cases in which hemoglobin was estimated, it averaged 78 per cent. The variations were from 20 to 90 plus per cent.

Stool.—Of seventeen cases tested for occult blood by the benzidin technic, positive reactions were obtained in four.

Test-meals.—Persistent, twelve-hour retention was demonstrated in eight instances (22+ per cent.).

Gastric Acidity.—In but five cases was absent hydrochloric acid proved. The average free hydrochloric acid for the group was 33 and the maximum 110. The average total acidity was 51.4. The maximum was 114. This was a short-term case (included in Group 3) in which pyloric stenosis with a palpable epigastric nodule was observed. Combined hydrochloric acid and acid salts averaged 14.2. The minimum was 0 and the maximum was 36. The presence of lactic acid was determined in the gastric contents from three cases (11 per cent.).

Altered blood was proved to be present in nine gastric extracts (28.8 per cent.).

The Wolff-Jūnghans test was positive in seven cases in the entire group. The formol index, as estimated by the formaldehyde titration method suggested by Sörenson and Schiff, averaged for the group 9.6. The minimum was 6 and the maximum 14. It would seem that this test, when interpreted in the light of clinical history and other laboratory data, promises to furnish an important point of differentiation between syphilitic and malignant lesions, inasmuch as we have shown that in a series of eighty-seven gastric cancers and *ulcera carcinomatosa* the average formol index was 21.

Microscopic Examination of Unfiltered Gastric Extract.—In these, using the colored-agar staining method, budding yeasts were demonstrated in eleven cases (43.3 per cent.); sarcinæ in four cases (15.3 per

FIG. 260.—Gumma involving pylorus and lesser curve of antrum and *pars media* of stomach (arrows). Note stiff appearance of stomach, due to cirrhosis, and clean-cut outlines of invasion of gumma into stomach lumen. (Original observation by author.)

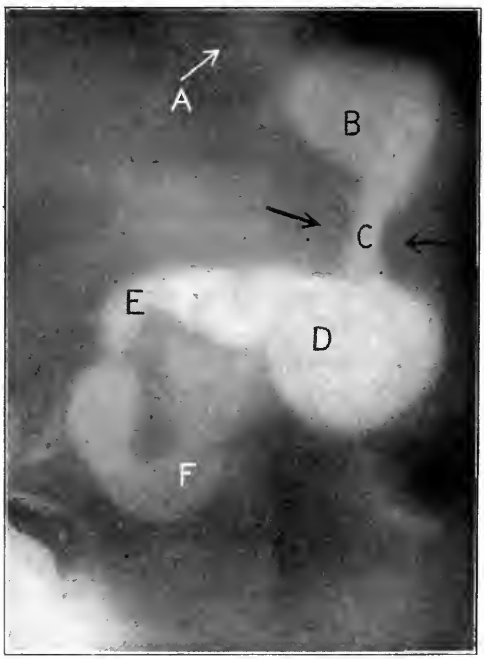


FIG. 261.—"Hour-glass" deformity of stomach, caused by gummatous infiltration of gastric wall. *A*, esophagus; *B*, upper loculus; *C*, site of gummatous stricture and canalization; *D*, lower loculus; *E*, duodenum; *F*, jejunum. Note rapid emptying of stomach, by gravity and not by peristalsis. (Original observation by author.)

cent.) and organisms apparently of the Oppler-Boas group twice (4.4 per cent.).

Information Derived from Roentgenoscopy.—Usually neither fluoroscope nor plate methods return pathognomonic signs. The roentgen method may ocularly demonstrate deformities in gastric contour, but, in the main, such deviations from the normal might readily be observed in benign or malignant peptic ulcer and in carcinoma, scirrhus or medullary. Not rarely, where hour-glass deformity is absent, —rapid gastric emptying is seen. Where hour-glass exists there may be lagging of the opaque meal in one loculus with early emptying of the other. Crater ulcers not rarely exhibit local retention flecks. These

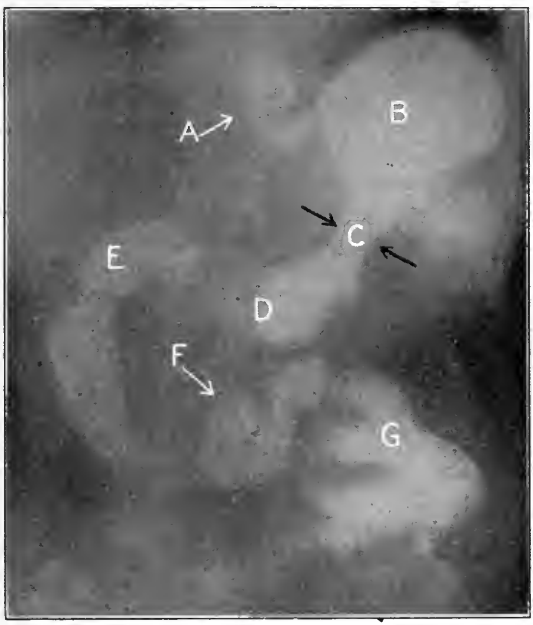


Fig. 262.—Extensive gumma involving stomach, causing "hour-glass" deformity. *A*, esophagus; *B*, upper loculus; *C*, canalization of *pars media; D*, small, lower loculus; *E*, dilated duodenum; *F*, diverticulum at duodeno-jejunal junction; *G*, jejunum. Note rapid filling of entire duodenum and a great part of the jejunum. (Original observation by author.)

may be multiple. Such are very suggestive, inasmuch as non-luetic gastric ulcer is seldom multiple. It has seemed to us that a roentgen sign of some worth is to be deduced from the rather anomalous finding of a clean-cut gastric tumor or deformity, associated with a poorly developed peristaltic activity, and with test-meal returns showing normal, or slightly reduced, free hydrochloric acid. When a positive Wassermann-Noguchi test is concomitant, the diagnosis is established with reasonable certainty. Not rarely, the roentgen demonstration of many small gastric nodules and multiple ulcerations or tumors prove suggestive enough to lead to the making of serologic tests and the beginning of specific therapy (Figs. 260, 261 and 262).

TUBERCULOSIS OF THE STOMACH.

This affection is very rare. It commonly manifests itself pathologically as ulceration, but it may be difficult to exclude a tuberculous etiology in certain instances of diffuse gastric cirrhosis.

The tuberculous lesion is probably most commonly caused by tubercle bacilli being deposited from the blood or lymph streams in the loose areolar tissue of the submucosa. A small round cell infiltration follows, circulatory disturbances result, and necrosis of the overlying mucus membrane occurs. In this way crater-ulcer, usually shallow but with ragged undermined edges, is formed. The edges are usually very vascular. The lesion is commonly solitary, but in rare instances of miliary tuberculosis, multiple small bleeding ulcers are found. It is uncommon for tubercle bacilli that are swallowed during the course of a lung tuberculosis to produce peptic ulcer. The pepsin and hydrochloric acid of the stomach usually render such swallowed bacilli inert. In instances where the sputum is particularly rich in bacilli and rapid emaciation has caused gastric juice of low hydrochloric acid content, direct invasion of the gastric mucosa at points of local injury may be possible.

Diagnosis.—The diagnosis of tuberculous ulcer of the stomach should be suspected in all instances where an extra-gastric tuberculous focus has been proved to exist and where there occurs a dyspepsia exhibiting an ulcer syndrome. In tuberculous ulcer, the symptoms are quite similar to those manifested by gastric ulcer due to other causes.

Fluoroscopy usually demonstrates a large shallow crater-ulcer with gastric deformity and retention of flecks of the opaque roentgen-meal. In rare instances, tubercle bacilli may be found in the gastric contents or the stools, when such have been well extracted with normal salt solution and centrifugalized fractionally, prepared for staining by the antiformin method and then colored by the Ziehl-Neelson technic.

CANCER OF THE STOMACH.

Definition.—A disease of the stomach, produced by the growth of a neoplasm in its wall. The affection is commonly of a perniciously progressive nature and occurs with the greatest frequency between the ages of forty and seventy years. Fatal termination is the rule. The disease is characterized clinically by imperfect gastric function. This malfunction is generally manifested by abdominal distress or pain, associated with loss of appetite and decrease in body weight, by weakness, anemia, cachexia, vomiting and the appearance of a supra-umbilical tumor.

The gastric extracts or the vomitus often exhibit deficient gastric emptying power, absent free HCl, altered blood and the presence of foreign organic acids, microörganisms and ferments.

When the stomach is filled with substances opaque to the roentgen ray, alterations from the normal contour are not infrequently demon-

strable upon fluoroscopic examination or when roentgenograms are made.

Incidence.—The recently compiled statistics of Hoffmann indicate that gastric cancer is increasing in frequency. The increase is real and not apparent merely as a consequence of more carefully tabulated mortality figures. In the civilized portion of the world it is computed that the general cancer death-rate has increased 23.3 per cent. in the past decade. It is estimated that there were 75,000 deaths from cancer in the United States in 1913. Of this number more than 28,500 (38 per cent.) were instances of cancer of the stomach.

The writer's study of 82,000 hospital admissions for all forms of medical and surgical ailment indicates that gastric cancer existed in approximately 1 out of 89 cases.

Age.—In the study of 921 operatively and pathologically proved instances of the disease, the writer found that the greatest number of cases was in the sixth decade of life. Between ages of forty to sixty-nine occurred 84.9 per cent. of all cases. Nineteen instances were recorded at or below the age of thirty-one. The youngest patient was eighteen (a female). In males, 40 per cent. of cases were between the ages fifty to fifty-nine; in females the greatest frequency was in the fifth decade (78 per cent. between ages forty to sixty-nine).

Sex.—Authors, studying material collected a half century ago, appear to establish that there is little difference in the sex incidence of cancer of the stomach. Recent observations would indicate that the disease is much more frequent in males than in females. Of 150 cases reported by Osler and McCrae, there were 126 males and 24 females. In the writer's 921 cases there were 693 males and 228 females, a ratio of approximately 3 to 1.

Race.—It would seem that people far removed from so-called civilized zones are but infrequently victims of the disease. It is doubtful if they are immune. More thorough medical scrutiny of causes of death among such people will probably disclose the occurrence of gastric cancer. Hoffmann's statistics indicate that negroes below the sixth decade are particularly non-resistant to cancer of the stomach. Of Friedenwald's cases, 5.2 per cent. were negroes. Miyake has reported the ailment among orientals. Our series indicates its occurrence among Italians, Mexicans, Portuguese and Alaskans, Hendley records 102 cancerous patients at Jeypore, India. It has frequently been stated that Jews are relatively free from gastric cancer. From a comparatively small number of Jewish patients, there were seventeen instances of the disease, 1.8 per cent. in the writer's 921 cases.

Heredity.—In our series a family or blood relationship history of cancer generally, was obtained in 8.5 per cent. The stomach was stated as being the location of the disease in 58.9 per cent. of this group. While heredity appears to play a part in the predisposition to cancer in certain families, yet its exact significance is not settled. The transmission of the same type of malignant tumor to homologous organs was emphasized by Virchow with respect to anal melanosis of horses. Slye

has proved the susceptibility to tumor implantation in certain strains of laboratory animals (mice).

With regard to heredity in humans, it is quite likely that the transmission by parents to offspring of a mode and conduct of life are factors. The conjugal state appears at times to influence the development of gastric cancer. In our series there were seven instances of the disease developing in man or wife within five months of its inception or fatal issue in the mate.

Social Status.—Material abundance in some way seems to favor the development of malignancy. Gastric cancer is relatively of more common incidence among the prosperous, overfed and physically underworked than it is among people who are actually struggling for existence. Hoffmann states that at the ages forty to fifty the proportionate mortality from cancer for males was 5.1 per cent. in the wage-earning group and 6.7 per cent. in the well-to-do division; it was for females at the same decade 13.7 for the wage-earners and 18.5 for the prosperous At the age of forty-five and over, the cancer mortality for overweights was 15.6 per 10,000 and for underweights 12.0 per 10,000.

Occupation.—No type of work appears to have direct influence upon the frequency of the disease. A sedentary life following a previous active career seems to favor gastric disturbances and with such, cancer. The ailment is very common among farmers or people dwelling in rural communities. These made up more than 40 per cent. of our series. Ochsner has emphasized the relationship of excessive ingestion of contaminated fruits and vegetables to malignant disease of the stomach. Such food is consumed in large quantities by those dwelling in rural regions.

Habits.—There is no actual proof that excessive indulgence in alcohol or the use of tobacco predisposes to gastric cancer. Groups of statistics supporting or refuting this statement may be readily compiled. In our series, but 5.3 per cent. of the patients were heavy drinkers and but 15.1 per cent. were excessive smokers.

Trauma.—Injury to the stomach may be mechanical, chemical, biochemical or parasitic. The injury may be internal or external. If the trauma is internal, it must doubtless be long maintained and be preceded by alterations from the normal in the gastric mucosa, before it is capable of causing malignant change. It is conceivable that in such circumstances, irritation from very hot or cold foods, hard pieces of food, foreign bodies, alcohol, tobacco juice, substances formed as a consequence of food deterioration or parasites (*e. g.*, nematodes as shown by Fibiger in rats) may have influence in initiating cancerous change or may aggravate an already existing lesion and prevent its spontaneous cure.

External traumata (blows, falls, crushing accidents, etc.) would at times seem to arouse latent processes to activity. In patients giving history of a chronic dyspeptic ailment, which has recently become continuous and is associated with constant weight decline, the factor of recent abdominal injury should be always considered. Of the writer's cases of gastric cancer, there was a history of external trauma in 1.5 per cent.

Hygiene.—Overcrowding, lack of sunlight and good air, personal uncleanliness, overfeeding, rapid eating, lack of attention to the teeth and mouth and a neglect of latrines, wells, milk houses and barnyard seepage, would appear to have contributory influence toward the aggravation of simple dyspeptic disturbances and hence, the greater prevalence of malignant affections.

Previous Diseases.—(1) *Gastric Ulcer* (see page 640). Unless especial attention is directed toward analysis of the patient's gastro-intestinal history previous to the onset of the evidently malignant affection for which he presents himself, it is very easy to miss evidences of prior gastric malfunction. The early affection is so frequently overshadowed by the existing ailment that it escapes notice and record. It should be recalled that the clinical symptomatology of peptic ulcer is extremely varied. Moreover, the pathologic significance of what in former years were called "hyperacidity," "acid dyspepsia," "gastritis," "catarrh of the stomach," "Reichmann's disease," "nervous indigestion," etc., is now more fully appreciated: such terms commonly conceal peptic ulcer. It is impossible to state how many ulcers become cancers. It is of significance to know that careful analysis of the digestive history of patients previous to the onset of a malignant gastric disease indicates that gastric cancer most commonly terminates a long-term dyspeptic upset. In Osler's and McCrae's analysis of 150 cases of cancer of the stomach, 22 per cent. had had "dyspepsia" for more than one year before symptoms of cancer appeared. In the writer's 921 instances of the disease, 60.5 per cent. had been affected with ulcer-like "indigestion" for an average time of more than ten years prior to the development of a malignant disease. In but 32.1 per cent. was the disease, from its inception, continuously and progressively malignant and in persons who had before been sound, gastrically. Of chronic, calloused, gastric ulcers, excised at laparotomy, MacCarty demonstrated malignant changes in the edges or the bases of more than 70 per cent.

2. *Gastric Syphilis.*—Warthin's recent studies indicate that inasmuch as lues is a spirochetemia, lodgment of this organism may take place in the stomach wall.

Leutic ulcers, cirrhosis, or huge tumors may later develop. In the past, it is quite likely that certain leutic gastric lesions have been classed as cancer.

3. *General infectious ailments*, as tuberculosis, rheumatism, malaria, the acute fevers or exanthematous diseases would seem to predispose to cancer of the stomach only in so far as they lower resistance, both constitutionally and locally in the stomach.

Morbid Anatomy.—Clinically, the term "gastric cancer' includes carcinomata and sarcomata. Both types of neoplasm are malignant in the sense that they arise from tissue normally making up the stomach wall, are progressive in growth, bring about destruction of normal parts, produce useless malformations of the viscus and frequently involve adjacent organs by direct extension, or distant organs by metastases.

If left undisturbed, both carcinomata and sarcomata cause death of their hosts.

SARCOMATA.—Sarcomata comprise less than 5 per cent. of all primary gastric tumors. Clinically, as pointed out by Yates, Campbell, Clendenning and others, this type of malignant neoplasm is generally diagnosed carcinoma. It requires pathologic study of excised tissue to establish the true nature of the growth at laparotomy.

CARCINOMATA.—Carcinomata comprise nearly 94 per cent. of all clinically and pathologically known forms of gastric neoplasms. Certain gross and microscopic appearances of gastric cancers have led to a histopathologic grouping. These differences in structure of cancers in the stomach occur as a consequence of attempts at defence on the part of the invaded tissue and progressive and retrograde changes in the substance of the neoplasms themselves. Grossly, gastric cancers are classed as:

1. *Fibrous Cancer* (*Scirrhus; Carcinoma fibrosum*).—This is usually a dense, well delimited growth, poorly vascularized and without tendency to necrosis and ulceration. The tumor often forms well delimited nodules and the stomach wall is commonly thickened, stiffened and is firm and unyielding to the touch.

2. *Medullary Cancer* (*Fleshy, cauliflower, cellular and vascular type; carcinoma medullare*).—A form of rapidly growing neoplasm arising in the structure of the mucosa and submucosa. The result is a soft, nodular mass, protruding into the lumen of the stomach. Ulceration and hemorrhage occur early. Metastases and direct extension to adjacent viscera develop quickly. Histologically the growth is commonly *adenocarcinoma.*

3. *Ulcerating Cancer* (*Ulcus carcinomatosum*). — At laparotomy, the most common form of malignant gastric neoplasm. The tumor develops as a consequence of cancerous change in preëxisting calloused peptic ulcer or occurs from secondary sloughing and ulceration of other types of cancer. The size of the tumor varies greatly: it may be well delimited and but two or three centimeters in diameter or it may be so extensive as to involve more than a fourth of the viscus. Its edges are not infrequently soft, ragged, vascular and undermined, but may be smooth, shiny and terraced. Its base is commonly firm. Malignant invasion of perigastric lymph-glands frequently takes place early: the metastases may be out of all proportion to the size of the local gastric disease.

4. *Colloid Cancer* (*Gelatinous or mucoid cancer; carcinoma colloides*). —A diffuse, infiltrating type of tumor, which, as a consequence of mucoid degeneration of its component cells or because of their excretion of a substance resembling egg-white, presents a water-logged, translucent, jelly-like appearance. Ulceration occurs early and rapid spread, with metastases is the rule. Colloid cancer is the least common type of gastric neoplasm, excluding sarcoma.

Histologic studies of gastric neoplasms indicate that, in all such growths, their macroscopic character is due to attempts at resistance and repair by the invaded tissues and to progressive and retrograde

changes taking place in the tumor mass itself. It is not uncommon to find, locally, scirrhus, medullary, ulcerating or even colloid areas in some growths. This is particularly the case in specimens removed at necropsy. The essential features, histologically, of gastric cancers are: atypical hyperplasia of the gastric glands and proliferation of cells originally lining the gland tubules in a functionally undifferentiated form, hyperplasia of invaded tissue, protective repair by scar tissue and degenerative changes (as shown by sloughing, hemorrhage, necrosis, cyst formation and areas of mucoid or colloid transformation with occasionally calcification).

Location of Gastric Cancers.—From study of specimens obtained at necropsies when subjects have died from uninterrupted malignant gastric neoplasms, it is impossible usually to determine at what part of the stomach wall such growths arose. Only from consideration of tumors observed at laparotomy, before extensive spread has occurred, can the actual starting-points of such be even approximately determined. It is thus quite evident, that masses of statistics which have as their basis necropsy reports collected from various unrelated sources, can convey no accurate knowledge concerning the primary origin of cancers of the stomach. Necropsies are largely of service in demonstrating how great or small the damage done by gastric cancer need be to produce a fatal termination in the individual host.

A recent study made by the writer of 953 operatively and pathologically demonstrated cases of gastric cancer, the subjects being in the main laparotomized, indicates the situation of cancer of the stomach as follows:

Situation.	Number of cases.	Per cent.
Pylorus	353	37.0
Antrum and lesser curvature	277	29.1
Posterior wall	65	6.8
Cardia	48	5.1
Greater curvature	14	1.5
Anterior wall	11	1.2
General	152	16.0
Not definite	33	3.3
Total	953	100.0

These figures are to be contrasted with those derived from studies of postmortem or unproved clinical material (W. Welch). It is of significance to observe that the situations of gastric cancer in the wall of the stomach correspond quite closely to those determined for the location of chronic, calloused peptic ulcer, as demonstrated by the writers tabulation of 544 proved instances of that disease. This is shown by the following table.

Situation.	Number of cases.	Per cent.
Pylorus	255	46.9
Prepyloric zone	19	3.5
Lesser curvature	168	30.9
Cardia or adjacent to it	39	7.1
Posterior wall	46	8.4
Anterior wall	17	3.1
Total	544	99.9

Secondary Cancer of the Stomach.—These are rare. In a study of 921 cases of gastric carcinoma there were 16 instances (1.7 per cent.). Secondary invasion of the stomach was associated with cancer of the breast (5 cases), malignant disease of the female genitalia (3 cases), cancer of the liver (3 cases), cancer of the gall-tract (2 cases), neoplasms of the colon (3 cases). History of previous operation or existing disease of the breast, pelvic organs, gall-tract or colon should direct attention to the stomach, particularly when these affections are followed by or are associated with dyspeptic upsets.

Changes in the Stomach Produced by the Growth of Gastric Neoplasms.—These are gross, histologic and functional, secretory and motor.

Gross Changes.—Except in cases of early annular growths at the pyloric portion of the stomach, the development of a gastric neoplasm always results in diminution of the size and capacity of the viscus. Where annular growths cause interference with the exit of gastric contents, the stenosis causes, for a time gastric dilatation with increased capacity. If the pyloric tumor be slow-growing, especially if it be of the "scirrhus" type, then dilatation of the stomach may be enormous. It keeps pace with the degree of pyloric stenosis. Usually, however, the primary pyloric tumor spreads to adjacent parts of the stomach wall, and although the stomach may remain large, protrusions of the growth into its lumen result in decreased capacity.

A tumor at the *cardia* frequently brings about such a high degree of stenosis that the esophagus above it becomes dilated. It may hold several liters. Below the cardia the stomach remains small, largely as a consequence of having little work to perform. Its capacity may be greatly reduced if the tumor at the cardia or at the fundus extend into its cavity. Neoplasms of the *pars media* (lesser or greater curvatures) generally cause the greatest degree of gastric deformity. Such growths protrude into the gastric lumen and often cause obstructions with division of the stomach into two ("hour-glass") or more loculi. Tumors of the *pars media* not rarely invade the pancreas, colon or liver or fix the stomach to the spleen or the left kidney. Cancer at the *pyloric* end of the stomach early causes obstruction and gastric retention or stagnation. Such tumors may for a long time remain unattached to neighboring viscera, and freely movable. They not infrequently lie at or below the navel when the patient stands erect. On inflation of the viscus with air, their change in position is sometimes remarkable. Some pyloric or antral growths become fixed early and are then but relatively mobile. Such limitations in movement occur because of direct extension to the head of the pancreas, the gall-tract or the liver, the omentum, large or small gut, the abdominal wall or the retroperitoneal tissues. Early metastases to the perigastric lymph-nodes generally produce varying grades of fixation of the pyloric fourth of the stomach. These are most common in instances of rapidly growing, medullary cancer.

Metastases in Gastric Cancer.—Enlargement of perigastric lymphatics occurs in more than 70 per cent. of instances of the disease. As MacCarty and Blackford have pointed out, the extent of perigastric lymph-node invasion bears little relation to the size of the primary process in the stomach wall: the size of the individual lymph-glands is no evidence as to whether or no they contain malignant tissue; malignant glands are usually hard to the touch and their cut surfaces appear glistening white. Upon the extent of lymph-gland invasion depends the prognosis, in a given case. This is wholly independent of the size, mobility or histopathologic character of the primary stomach tumor. Lymph-glands most commonly involved, in addition to those directly about the stomach, are those along the spine and in the rectovesical space, in the mediastinum and above the left clavicle and the inguinal group. The navel may be fixed and the seat of a firm, occasionally ulcerated growth.

Metastases to the *liver* occur in from 15 to 35 per cent. of all cases of gastric cancer, depending upon the stage of the disease at which the growth is interrupted and upon the histologic nature of the tumor. In the writer's series, the liver was involved in more than 18 per cent. Liver and gall-tract metastases may result in portal obstruction and *ascites*. This may develop very rapidly, especially if there has been early spread of the cancer directly to the *peritoneum*. Involvement of the pleura, pericardium, mediastinal lymphatics or the lungs occurs in from 5 to 11 per cent. of all instances of the disease. When the pleura is invaded *serous exudation* appears early. The puncture fluid not infrequently contains red blood-cells, endothelial cells presenting atypical, mitotic figures and, as Roger Morris has pointed out, an increase in the volume of incoagulable nitrogen. If the lung tissue be invaded, malignant consolidation or necrosis with hemorrhage or abscess occur.

Symptoms and Signs.—As a result of recent pathological and clinical investigations, it is now possible to state that much of the burden of the early diagnosis of gastric cancer rests upon the observations of the skilled surgical pathologist; that such diagnosis is best made from careful study of the histological variations occurring in recently extirpated tissue; that the malignant departures from the normal are least evident in tissue removed from subjects whose gastric history has been that of recurring peptic ulcer, and in whom the ailment appeared to be but ulcer of this type to both the eye and the hand at laparotomy. These ulcers are commonly greater than 2 cm. in diameter.

While these recently established facts impose a new responsibility upon the pathologist, it should be emphasized strongly that the laboratory worker is dealing with a picked material: the segregation of patients must be made by clinical analyst, internist and surgeon. The patient's fate depends in direct ratio upon the completeness of the coöperation existing among the three. In their hands, likewise, rests the problem of substantially reducing the mortality of the race from gastric cancer. As an attempt to further this object, the writer presents

briefly certain facts derived from a clinical study of his records of 921 operatively and pathologically demonstrated instances of cancer of the stomach. This study indicates that the cases of gastric cancer arrange themselves into the following well-defined clinical order:

Clinical Grouping.—(1) A symptom-complex of two very *definite and different* stages: (*a*) gastric disturbance, non-malignant and generally chronic; (*b*) gastric malfunction of malignant type. (2) A symptom-complex generally of a distinctly apparent, pernicious nature. (3) A group of cases in which there is usually evidence of years of gastric disturbance of irregular form clinically, on which is superimposed a type of affection easily recognized as malignant.

GROUP 1.—*Symptom-complex wherein Two Definite and Different Stages of Disease are Present.*—This group furnished 61 per cent. of our series. The average duration of all symptoms in the first stage was 11.7 years. The average duration of all symptoms in the second period is nearly six months. The two periods differ markedly. The anamnesis brings out very well the characteristic manifestations of each period. It is only by disengaging the patient from his present state and endeavoring, definitely, to locate his first departure from gastric health that one gets the key to the situation.

In 61 per cent. of our proved cancer cases the total time of gastric complaint was somewhat over twelve years. For practically $11\frac{1}{2}$ years the symptomatology was that which, clinically, we associate with chronic gastric ulcer. This first period was characterized by a long series of *attacks* of "*indigestion.*" These attacks were associated with *epigastric distress* or *pain* in 88 per cent. of instances. In 85 per cent. the distress had some relation to the taking of food, the pain-free interval being long or short according to kind of food eaten. After a solid, mixed meal, the pain relief was longer, but when it recurred it was unmistakably more severe than when lighter forms of nourishment had been indulged in. Other forms of pain relief were alkalies, vomiting and diet. In 54 per cent. of instances the pain was referred to some part of the back. The appetite was usually limited by the fear of taking food and thus causing pain, or by the dread of bringing on bleeding. The food desire in this first stage was generally strong. Weight was lost in the attacks but gained between them. The average *weight loss* at this period was 17.4 pounds. *Constipation* was noted in 52 per cent. of instances. In 8 per cent. there was diarrhea. *Vomiting* occurred in 60 per cent. Rather more than 70 per cent. vomited in attacks. The time of vomiting was generally when distress was most marked. *Bleeding* (hematemesis or melena) was noted in 17 per cent. of instances during this stage. Of the whole number bleeding, 49 per cent. had bled at least two years prior to coming under observation. Of those who bled within the two-year period over 65 per cent. were of the group with long previous history. In this group *anemia* was rarely marked, the average hemoglobin being about 80 per cent. (Tallquist or Dare).

If this class of case pursues the above outlined history, the fol-

lowing may ensue: (1) Complete healing with stoppage of all symptoms; (2) typical chronic, *benign* gastric ulcer may result, or (3) gastric cancer may form, whereas previously there had been but a benign process. And no one can prognose in a given case presenting the clinical picture of gastric ulcer just *which ulcer will heal or continue its benign course or which will ultimately form the suitable ground for cancer.* When we recall the pathology in these cases we can hardly blame ourselves for not catching the ulcer clinically in transition to cancer. All ulcers have about and in them hyperplastic tissue—tissue of defense and of healing. No one can tell in a given case when this hyperplasia will change over from the simple type to the malignant form. *Clinically* we are only warned by the appearance in a patient of a more or less *continuous* gastric disorder, where *attacks* had before been the rule. This may occur with or without the onset of pyloric obstruction. Where previously there was trouble in spells, with food relief, we note food aggravation, night distress, delayed vomiting, continuous presence of occult blood in the stools, anemia, cachexia, weight loss steadily maintained, weakness, and that peculiar, hopeless apathy exhibited by the *facies.* Pain is rarely marked. Vague distress, "heavy feeling" or soreness in the epigastrium is the rule. Severe pain was observed in but 19 per cent. of our cases. It was of "colicky" nature in 14.2 per cent. Gassy and bloated sensations are generally constant and annoying.

In this second stage vomiting becomes more constant and is frequently of greater amount. The odor of the vomitus changes from distinctly sour or yeasty to cheesy or rancid. The color of the vomitus may exhibit little if any alteration. Inasmuch as more than 94 per cent. of our cases of gastric cancer were of the medullary type, oozing of blood was not uncommon. This pathologic state usually imparts a tan to deep brown color to vomitus or stomach extracts. In rather more than 17 per cent. of our cases of gastric cancer was the vomitus of the classic "coffee ground" color. When it presented these characteristics the disease was far advanced in 84.2 per cent. of instances, and inoperable (so far as resection was concerned) in 77 per cent. The vomitus generally exhibits excess of thick, tenacious mucus, intermixed with sizable food remnants, frequently poorly chymified.

The stools rarely show macroscopic changes unless hemorrhage complicates, or liver, pancreas or adjacent hollow viscera become involved. On a milk diet, chemical tests for blood were positive in 93.4 per cent. of cases tested.

GROUP 2.—*Symptom-complex in Cases Clinically Malignant from the Inception of Gastric Malfunction.*—Of the 921 cases 31.6 per cent. fell in this group. Careful history taking failed to elicit any clinical type of gastric complaint in these patients previous to an average time of 6.4 months before they came under observation. It should be emphasized that because no gastric disturbance had been previously noted, the conclusion should not be forced that these patients had had no gastric pathology previously. On the contrary, our postmortem or laparotomy

findings of healed ulcers, and even of gastric new growths in individuals who had no clinical symptoms referable to gastric disease, should lead one to exercise caution in insisting when or how malignant processes arise in the stomach. The longest history of gastric symptoms in this group extended over nearly three and one-fourth years; the shortest, barely three weeks.

In this group, which we have, from the pathologic view of the disease, styled "primary" gastric cancer, often it is extremely difficult to state from clinical presentings just when cancer began. Many so-called "primary" cancers have histories extending over weeks of time, where the symptom-complex closely approximates that which our present-day vogue associates with gastric ulcer of the continuously active and progressive form. The clinical picture is different, however, in one important respect: to that symptom-complex are added the manifestations of a malignant systemic poisoning. Instead of fairly definite attacks of ulcer type of dyspepsia, and these alone, the process is continuous and associated with progressive weakness, anemia, weight-loss with cachexia and vomiting, changing rapidly to the rancid kind. Epigastric pain may be severe and prostrating at first, but later moderates in severity. It is not relieved, but is aggravated, by food intake. It ultimately becomes continuous. The writer has frequently had strikingly impressed upon him the "ulcer features," clinically, in primary gastric cancer. The hurried progression to definite malignancy has seemed to emphasize the necessity for separate recognition clinically of the term "chronicity" in its pathologic sense and in its time-duration sense, that is, signifying weeks, months or years continuation of disease. In many of these "primary" gastric cancers, the clinical gamut of "gastritis," "ulcer" and "cancer" may be run in a few months or even weeks. The whole course of the ailment is then compressed into a sort of tabloid with regard to time: from this course, parts are readily segregated which closely approximate, clinically, those stretching over years, as exhibited by the great mass of cancers forming Group 1. With this state of affairs, it is not to be wondered at that patients present themselves to the specialist or to the surgeon only when tumor appears in the epigastrium or when hopeless cachexia warns of impending death.

While the above type of onset of "primary" gastric cancer is not infrequent, fully two-thirds of this group have more or less vague recollections of how they were affected gastrically before loss of appetite, weakness, mental inertia, abdominal distress or epigastric "hardness," "knob," or "lump" warned them that something graver than "chronic indigestion," existed. Rarely is the transition from perfect gastric health to their present state a rapid one. Aversion to certain forms of food (meats, milk, sweets or legumes) is not infrequently an early symptom. While the appetite for certain foods may be keen, the aversion to others may be marked and, for the individual, radical. Eructations, often of extremely disagreeable taste, may become pronounced early. Gassy abdominal distention may be troublesome. Unexplained nausea with or without physical weakness is manifested.

In 17 per cent. of the cases of this group, diarrheic stools appeared without apparent cause. Vomiting may be the first symptom and its copiousness pronounced and alarming. It is commonly bitter, sour, cheesy, or is described as "rotten" in taste. Vomiting was observed in 79 per cent. of this class. In 64 per cent. of those vomiting, it was a daily event. In more than 80 per cent. of these "delayed" vomiting was exhibited.

Consideration of the types of case making up our grouping of "primary" gastric cancer would be incomplete without mention of that class which it is appropriate to style *"fulminant" cancer.* In this series, such comprised 7.7 per cent. of cases. The whole history of the affection up to the time of laparotomy covered less than ten weeks. The average age of these patients was forty-six years. In this subgroup, profound cancer intoxication was pronounced from the time of the first departure from gastric health. In 11 instances fever rose as high as 102° F. The leukocytes averaged 12,400. Anemia was of lower degree than is usual in gastric cancer. The hemoglobin averaged 56 per cent. Weakness, weight-loss, mental dulness, foul eructations and copious vomiting, marked gassy distention of the epigastrium, abdominal soreness and the appearance of a rapidly enlarging supra-navel mass occurred with astonishing speed. At operation, the malignant process was always irremovable and perigastric lymph-gland invasion was extensive. The pathologic examination of tissue removed, showed cancer of the medullary type.

GROUP 3.—*Gastric Malignancy following Long History of Clinically Atypical Dyspepsia or Dyspepsia Considered Dependent upon Extragastric Causes.* Five and one-half per cent. of cases make up this division. Careful history taking brings out two markedly different types of gastric malfunction. The clinical manifestations preceding those evidently malignant, extended over an average period of rather more than nine years. The time taken up by the supervening malignant stage averaged rather more than five and one-half months.

The clinical symptomatology of the affections, while they were apparently of benign nature, usually pointed toward disease of the gall-bladder, appendix, large bowel or the pancreas.

The clinical symptomatology of this class of case, was, when the malignant period supervened, in every way similar to that of the second period of the cases making up Group 1 or of some portion of that exhibited by those in Group 2. The point to be emphasized is, that after years of gastric departure from health, of atypic form but evidently benign so far as our clinical knowledge extends, the picture changed abruptly to that of definite malignancy. It is only in those patients who had but recently submitted to laparotomy for extragastric disease, however, that we can positively state that gastric ulcer or gastric cancer, with atypical manifestations, had not existed for some time previous to that terminal stage of evident malignancy, clinically.

Prominent Clinical Signs and Symptoms.—(*a*) HEMORRHAGE.—*Macroscopic.*—Of the whole number of cases making up this series, gross

evidences of bleeding were recorded in 18.5 per cent. Of the whole number bleeding, 17.4 per cent. had exhibited hematemesis or melena at least two years before coming under observation. In the large majority of instances, where such early bleeding had been noted, the "precarcinomatous" history conformed to that which we interpret, clinically, as chronic peptic ulcer.

Chemical Test for Blood.—In the gastric extracts, such was positive in rather more than 88 per cent. when tested by the guaiac or the benzidin methods. The stools examined after patients had been upon meat-free diet gave positive chemical blood test in rather more than 93 per cent. of cases.

The interpretation of chemical tests for blood in stool must be carefully controlled. In those instances where there is a slowly progressing malignant ulcer, benzidin or guaiac tests are apt to be positive only intermittently. Given an ulcer history in an individual past middle life, the persistent demonstration of altered blood in the stools is of considerable significance toward the probability of malignancy. It is thus seen, that positive occult blood-tests are of greater service in giving information with respect the histopathology of a peptic ulcer than in merely demonstrating that an ulcer exists. It would also appear that chemical tests for blood, in the properly prepared stools, furnish a valuable and early diagnostic sign of gastric cancer. This is to be especially emphasized when it is recalled that *ulcera carcinomatosa* are the forms of gastric cancer most amenable to surgical treatment. In cases where gastric cancer was well advanced chemical tests for blood were positive in more than 98 per cent. of the stools examined. Of course when this finding was noted, other evidences of gastric cancer were usually not lacking.

(*b*) VOMITING.—This is generally due to a persistent mechanical fault in the emptying power of the stomach. The mechanical hindrance to the passage of food from the stomach most commonly occurs earliest as a consequence of varying grades of stenosis, associated with what, clinically, appears chronic peptic ulcer. In this type of case, vomiting is at first intermittent but later becomes persistent. This clinical hint, especially if it is associated with a history of ulcer dyspepsia, in any patient should point to prompt surgical procedures. Such radical measure often leads to the demonstration of well localized gastric cancer and permits of its complete extirpation. When cancer has become far advanced, vomiting is a prominent symptom in nearly 80 per cent. of cases. When the tumor involves the cardia, the fundus or the pars media (with or without hour-glass formation) vomiting is very apt to occur shortly after food has been swallowed. The vomitus is then rarely copious or of disagreeable appearance or odor. When the lesion is at the antrum or the pylorus, the vomitus is often tan or brownish in color, cheesy or rancid in odor, may contain chunks of poorly chymified food and is commonly copious. "Coffee-ground vomitus" generally occurs in instances of hopeless malignancy. Diagnosis of gastric cancer should not be postponed until the appearance of such vomitus.

(*c*) The Abdominal Tumor.—In instances of gastric cancer where the diagnosis rests upon microscopic examination of extirpated tissue, but rarely is it possible to demonstrate abdominal tumors. The few cases where ridges or suspicious indurations are made out, occur in conjunction with chronic, perforating ulcers of malignant type, associated with exuberant scar-tissue proliferation. In the writer's series 33.7 per cent. of the cases exhibited no abdominal tumor prior to laparotomy. In this group of cases, occurred the highest percentage of operative cures. Abdominal tumors or ridges were definitely made out at the first examination, or after air inflation of the stomach, in 66.2 per cent. In rather less than one third of such instances, were the surgical advantages of a localized disease present at laparotomy. From these facts it is quite evident that diagnosis early enough to be of definite service to the patient must usually be made before it is possible to palpate an abdominal mass. In about 9 per cent. of even well advanced gastric cancers, it is not possible to palpate an abdominal tumor. This class is made up of growths located at the cardia, high on the lesser curvature, at the fundus, or on the posterior wall. Where the neoplasm is of the diffusely infiltrating type (scirrhus or colloid), the abdominal wall is tense or the peritoneal sac distended with free fluid, even extensive gastric cancers with metastases may be not associated with palpable abdominal tumor.

Location of the Abdominal Tumor.—Of our series, the palpable nodular mass was located in the epigastrium in 85.7 per cent. In 13 per cent. the growth was about the navel. In but 1.3 per cent. was the tumor demonstrated below the navel.

The following table demonstrates the positions in which we determined palpable tumors:

Location.	Number of cases.	Per cent.
Right upper quadrant	199	32.6
Left upper quadrant	165	27.1
Midepigastrium	73	11.9
"Pit" of stomach	47	7.7
Epigastrium, general	31	5.1
At navel	27	4.4
Right of navel	38	6.2
Left of navel	21	3.4
Below navel	8	1.3
Total	609	99.7

(*d*) Cachexia.—Cachexia is a manifestation of late gastric cancer. When pallor, definite anemia, physical weakness, mental lassitude, and loose, dry skin, with or without edema about the malleoli, are noted the cases are hopelessly involved by the neoplasm in more than three out of four instances. Cachexia is rarely a sign of definite note in early gastric cancer, whether such growth follows a previous long-term dyspepsia or has arisen abruptly from what we are apt to consider a healthy gastric mucosa. The diagnosis which requires evidences of systemic cancer poisoning for its substantiation is of interest only so

far as personal satisfaction is concerned. Early, fatal termination of such case can usually be safely prognosed. In these instances, palliative operations only are possible.

(*e*) TEST-MEAL ANALYSES.—Persistent interference with the free emptying power of the stomach is a sign of great worth in the early diagnosis of gastric malignancy. It at once indicates a mechanical fault that cannot be permanently treated by non-surgical procedures. If the individual in whom such interference to free gastric emptying is noted has been a chronic dyspeptic, and his dyspepsia has been clinically of the ulcer type, one must consider that he is dealing with a condition which is potentially cancer, if not actually so. In this very group of cases, surgical exploration reveals the greatest percentage of early gastric cancers, and from this class, are returned the greatest number of permanent cures of the disease.

Proof of gastric emptying power should always be determined by the administration of a mixed meal consisting of a liberal allowance of ordinary food. Meals of the pap variety are practically of no value in determining gastric emptying power. The persistent demonstration of test-food remnants in a stomach from eight to twelve hours after taking, means a mechanical fault.

In our gastric cancer series, gastric emptying power was interfered with in nearly 71 per cent. of instances. Food stagnation was demonstrated approximately 10 per cent. more frequently in instances of the disease that had been shown to be malignancy following long-term, clinically benign dyspepsia than where the ailment was "primary" cancer.

Gastric acidity estimations are of considerable worth if properly interpreted. The quantitative fluctuations in free hydrochloric acid are of greater value prognostically than diagnostically. A carelessly compiled literature has conveyed the impression that gastric cancer and absent or low free hydrochloric acidity go hand in hand. As a consequence, not a small portion of the mortality from cancer of the stomach can be traced to the physician's persistently treating the dyspeptic medically until free hydrochloric acid has entirely disappeared—and with it the patient's chance for cure.

In but 52.4 per cent. of our cases of gastric cancer was free hydrochloric acid absent from the removed test-meals. Where free acid was present, it ranged from a trace to as high as 160. Approximately one out of five cases had free hydrochloric acidity between 20 and 50.

In inoperable, ulcerated, primary gastric cancer, the average free HCl was 2.4. The average total acidity was 28.

In operable gastric cancer without gross evidences of ulceration, the average free HCl was 6.4. The average total acidity was 28.

In ulcera carcinomatosa (commonly operable, with a high percentage of permanent cures), the average free HCl was 31. The average total acidity was 48. These figures closely resemble those returned from the analyses of gastric extracts in instances of chronic benign peptic ulcer,

even when interpreted in the light of clinical history. However, in a given case, the progressive lowering of the free HCl and a corresponding increase in the combined HCl, associated with permanent interference with the gastric emptying power and the persistence of altered blood in the properly prepared stool, necessitates the advice that laparotomy should be performed on the suspicion that malignancy is present.

Lactic acid, clinically, means gastric stagnation in the presence of diminished free HCl. It is rarely demonstrated when free HCl is higher than 15. It was demonstrated in rather more than 52 per cent. of the cases in our entire series. In nine out of ten instances where lactic acid was present in the gastric extracts, irremovable malignancy (stomach, perigastric lymph glands, adjacent viscera) was found at laparotomy. It is thus seen, that the proof that lactic acid exists in test-meal specimens has an interesting prognostic value. It usually means that hopeless cancer is present. In about 48 per cent. of gastric cancers, however, lactic acid cannot be demonstrated in the test-meal. In this very group we have those instances of the disease most amenable to surgical treatment.

The Significance of the Demonstration of Specific Ferments in Gastric Cancer.—The Formol Index.—In the early diagnosis of neoplasms of the stomach, it would seem that the estimation of the ereptic power of gastric juice toward peptone solutions is of considerable value in supplementing the clinical history and the other examinations. In a recent study, using the formaldehyde titration method suggested by Sörenson and Schiff, we were able to demonstrate rather characteristic findings in gastric cancer, particularly in *ulcus carcinomatosum*. The average formol index of 87 cases of proved gastric cancer was 22.3. The average index in 22 instances of *ulcus carcinomatosum* was 19.18; the average index in 99 cases of duodenal ulcer was 12.4; of 57 cases of benign gastric ulcer, 11.6; of 32 cases of benign achylia, 14.1; of 16 cases of pernicious anemia, 14.5, and of 5 cases of cancer of the liver, 4.25.

The Edestin Test (Fuld-Levison).—Our experience covers 108 cases. The work appears to indicate that early cases of gastric cancer, where the free hydrochloric acidity is low, are associated with high peptolysis and low proteolysis. In benign gastric ulcers, low readings for both peptolysis and proteolysis are obtained.

The Glycyltryptophan Test.—This reaction proved positive in approximately 40 per cent. of 186 operatively demonstrated instances of gastric cancer. The reaction has but a chemically interesting value, apparently, inasmuch as, in our cases, where positive tests were obtained, diagnosis was generally quite possible from the physical examinations.

The Wolff-Junghans' Test for Soluble Albumin.—From the examination of 230 instances of pathologically demonstrated gastric cancer (well established types of the disease and *ulcera carcinomatosa*) we obtained positive manifestations of the test in 80.1 per cent. There

were 15 instances of *ulcera carcinomatosa* examined consecutively in which positive Wolff-Junghans' reaction was positive in more than 90 per cent. Positive manifestations of the test were rarely obtained in cases of non-malignant achylia (extragastric malignancy, pernicious anemia, and the like). It would appear that this test, when taken as a part of evidence making for a complete clinical diagnosis, has suggestive pointings. The high percentage of positive reactions obtained in instances of *ulcera carcinomatosa* and early gastric malignancy of a fulminant type is not without clinical significance. It would appear to be an indication for laparotomy at a stage when the maximum advantage from localization of the disease can be secured.

The Microscopic Examination of Gastric Contents.—There is no characteristic microscopic picture of early gastric cancer other than that associated with gastric stagnation consequent upon the development of stenosing, calloused, peptic ulcer. In such event, the microscopic findings are those indicating simple, gastric fermentation as a result of active proliferation of yeasts and sarcinæ. When gastric cancer has become well established, and with it, varying grades of gastric retention are found, there is no microscopic picture more characteristic. Using the colored-agar method which we suggested some seven years ago, we were able to demonstrate organisms of the Oppler-Boas type in 94.1 per cent. of 172 consecutive instances of the disease. (See Figs. 249 and 250.) Yeasts were concomitant in nearly 31 per cent. Sarcinæ were associated in rather more than 10 per cent. Threads of streptococci were found in nearly 7 per cent., and were especially common in instances of non-stenosing malignancy. It is interesting to observe that when organisms of the Oppler-Boas type are present in gastric extracts, free hydrochloric acidity is below 10 in more than 90 per cent. of instances, and that an abdominal mass can be palpated in more than 3 out of 4 cases. The finding of an abundance of Oppler-Boas bacilli has a certain prognostic value, inasmuch as our study shows that in seven out of ten instances where such organisms were present palliative operations only were possible. The curable cases of gastric cancer are rarely associated with the demonstration of Oppler-Boas bacilli in gastric extracts. It is extremely uncommon to find bacilli of the Oppler-Boas type in instances of non-malignant disease associated with gastric stagnation.

Epithelial cells showing atypical mitoses, so-called "cancer-cells" were demonstrated in rather more than 1 per cent. of our cases. Occasionally, a growth situated at or near the cardia permits of the prompt recognition of such abnormal cells, and an early cancerous process may be diagnosed therefrom. As a rule, however, the finding of "cancer-cells" in the gastric extracts, indicates an extensively sloughing process or one so located anatomically (cardia, high lesser curvature, fundus) that excision is impossible, even though the disease be not far advanced.

(*f*) Blood Cell Changes.—*The Erythrocytes.*—Of 267 cases the erythrocyte count averaged 4,380,000. This number is rather higher

than that given by some investigators, (Cabot, 4,018,000 cells; Osler and McCrae 3,712,186). This is to be explained partly on the basis that many of our cases were diagnosed very early or that the larger number of patients studied returned a fairer average than would be returned by smaller lists. The minimum red cell count was 860,000 cells—a case of inoperable tumor with ascites and extensive general metastases. The maximum red cell count was 6,328,000 cells—an instance with extensive cancer of the lesser curvature and body of the stomach. In nearly 50 per cent. of our cases, the red count lay between four and five million cells.

It does not appear from the study of our cases that diminution in red cell count is greatly affected by metastases. On the contrary, in this study, a large group of cases with extensive metastases returned a somewhat higher average erythrocyte count than did those cases where metastases were absent.

Hemoglobin.—Of 454 cases examined, the hemoglobin ranged between 50 and 100 per cent. in more than 72 per cent of the patients. The average hemoglobin for the series was 64.3 per cent. The minimum was 25 per cent. and the maximum 97 per cent.

Color Index.—Of 267 consecutive cases the average color index was .73, the minimum was .32 and the maximum .97.

Shape and Size of Erythrocytes.—In well advanced gastric cancer, when the hemoglobin is below 75 per cent., it is not uncommon to find red blood-cells that exhibit wide variations in shape and occasionally in size. Our records detailed 17 blood studies where macrocytes were noted and 8 instances where megaloblasts were found. In 23 cases (10.7 per cent.) of patients of this group, normoblasts were found. Of 204 blood analyses where definite record of variations in the shape and size of the red cells were noted, in 40 per cent. the variation was recorded as being "slight," in 45 per cent. of "moderate degree" and in 14.7 per cent. "marked." Poikilocytosis, blood shadows or degenerative forms are quite common in the blood smears from late gastric cancer

TABLE SHOWING VARIATIONS IN ERYTHROCYTE COUNT IN 267 CASES OF GASTRIC CANCER.

Red cell count.	Number of cases.	Per cent.
Below 1,000,000	2	0.75
From 1,000,000 to 2,000,000	3	1.1
" 2,000,000 to 3,000,000	17	6.3
" 3,000,000 to 4,000,000	51	19.2
" 4,000,000 to 5,000,000	132	49.3
" 5,000,000 to 6,000,000	59	22.0
" 6,000,000 to 7,000,000	3	1.1
Average: 4,380,000 for	267	99.7

The Leukocytes.—In the writer's series there were 261 cases where white blood cell counts were made. The average count was 11,270.

The minimum count was 4200 cells and the maximum count 36,200 cells. The following table indicates the cell count range.

DEMONSTRATING VARIATIONS IN LEUKOCYTE COUNT OF 261 CASES OF GASTRIC CANCER.

Leukocytes.	Number of cases.	Percentage.
Between 4,000 to 5,000	15	5.7
" 5,000 to 6,000	17	6.5
" 6,000 to 7,000	33	12.7
" 7,000 to 8,000	56	21.4
" 8,000 to 9,000	31	11.5
" 9,000 to 10,000	27	10.3
" 10,000 to 11,000	18	6.9
" 11,000 to 12,000	15	5.7
" 12,000 to 13,000	6	2.3
" 13,000 to 14,000	16	6.1
" 14,000 to 15,000	9	3.4
" 15,000 to 16,000	3	1.1
" 16,000 to 17,000	3	1.1
" 17,000 to 18,000	2	0.76
" 18,000 to 19,000	3	1.1
" 19,000 to 21,000	5	1.9
" 21,000 to 37,000	2	0.76
Average: 11,270	261	99.22

It has been held that leukocytosis in gastric cancer is an index to the extent of the metastases, the rapidity of growth of tumors or such complications in the course of the ailment as hemorrhage or perforation. In our series, the cases with metastases averaged above 10,000 white cells in more than 75 per cent. of instances. In instances of the disease without metastases, the leukocytes were above 10,000 in 80 per cent.

Digestion Leukocytosis.—Müller and Capps state that digestion leukocytosis is absent in more than 80 per cent. of gastric cancers. Osler and McCrae claim that the presence of such leukocytosis is too uncertain to be of much assistance in diagnosis. Recently F. Banhoff has made a study of this phase of the leukocyte count. He claims that the observation of digestion leukocytosis is a valuable clinical aid in the differentiation between benign peptic ulcer and malignant peptic ulcer.

Qualitative Variations in Leukocyte Count.—In our series we have records of differential leukocyte counts in 160 cases. The following facts are of interest:

Polynuclear leukocytes averaged 73.2 per cent. The minimum was 56 per cent. and the maximum 86.4 per cent.

Small lymphocytes averaged 19.1 per cent. The minimum was 9.7 per cent. and the maximum 37.5 per cent.

Large lymphocytes averaged 3.41 per cent. The minimum was 0.7 per cent. and the maximum 13 per cent.

Basophile leukocytes averaged 1.28 per cent. The minimum was 0.3 per cent. and the maximum 5 per cent.

Transitional leukocytes averaged 1.58 per cent. The minimum was 0.3 per cent. and the maximum 6 per cent.

Myelocytes were observed in 28.8 per cent. where differential counts were made. The average was 1.27 per cent. The minimum was 0.3 per cent., and the maximum 3.3 per cent. Myelocytes were frequently noted where the red cell count was above 4,500,000 cells, but were observed in no instance where the hemoglobin was higher than 75 per cent.

Eosinophiles were noted in 67 per cent. The average was 4.01. The minimum was 0.3 per cent. The maximum was 7.7 per cent.

Serologic Analyses.—Proper standardization of the Abderhalden technic may result in valuable information being obtained in early gastric cancer. It would seem that this method of examination might prove useful where malignant gastric ulcer is suspected. Types of serologic investigations other than the Abderhalden test have yet to prove their worth as practical clinical procedures.

Facts Returned by Roentgen Examination.—When gastric cancer has become well established, roentgen study returns useful information in rather more than 90 per cent. of cases. In these cases, are shown alterations in gastric emptying power, changes in gastric peristalsis, deformities in the stomach outline, variations in the size of the viscus, abnormal gastric position, fixation to adjacent organs or, in a few instances, fistulæ.

In nearly 10 per cent. of our cases of gastric cancer, the roentgen examination *definitely proved the disease to exist,* where previously there had been only a suspicion that the stomach was involved by malignant disease. Cases of this type, are commonly instances where the tumor is at the fundus, the cardia, the posterior wall or high on the lesser curvature. In the differentiation between gastric and extragastric disease associated with tumor, fluoroscopic examination is of especial service diagnostically.

The very early cases of gastric cancer or of *ulcus carcinomatosum* rarely exhibit characteristic anomalies on examination by either fluoroscopic screen or *x*-ray plate. This is unfortunate because it is in just this type of disease that definite information is particularly desirable. When the disease is at this stage the greatest benefit is possible from surgery. *The surgical pathologist has taught us that chronic calloused or crater ulcers that have a diameter greater than 2 cm. are microscopically malignant in more than three out of five instances. The roentgen determination of a gastric ulcer of this type, particularly when such ulcer is located in the pyloric half of the stomach, should lead to a presumptive diagnosis of malignant ulcer and should suggest abdominal exploration. It would appear that an observation of this kind furnishes, in the large majority of instances, the earliest possible roentgen diagnosis of gastric cancer* (Figs. 263, 264 and 265).

When the roentgen examination gives gross evidences of gastric cancer other manifestations of the ailment are generally not absent. In a recent series of 121 of our cases of the disease, in which the roentgen findings by an expert were stated as "possible," "probable," or "typical" gastric cancer in 91.8 per cent., organisms of the Oppler-Boas type

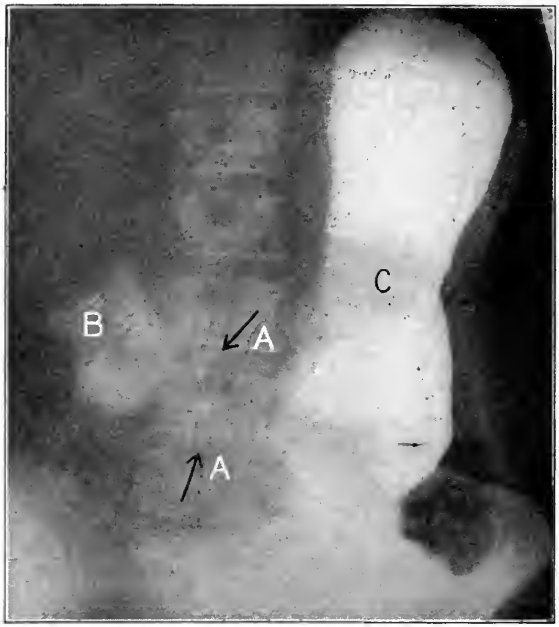


FIG. 263.—Moderately extensive cancer ("ring type") involving prepyloric zone and antrum and causing gastric retention. *AA*, cancerous area; *B*, partly visualized duodenum; *C*, enlarged stomach. Contrast ragged outlines of cancer with sharp margins of gumma (Figs. 259, 260 and 261). (Original observation by author.)

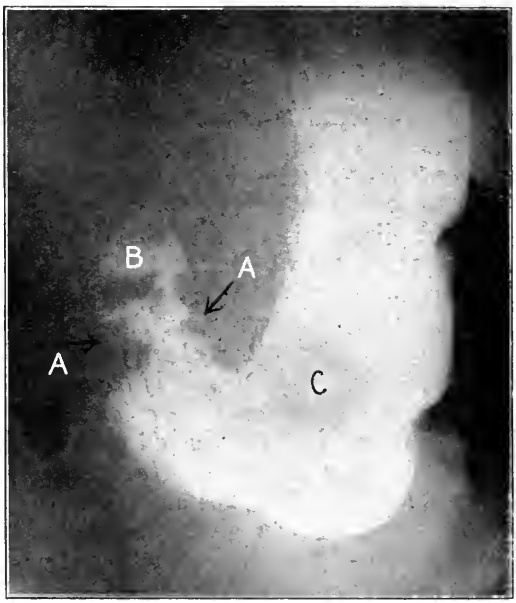


FIG. 264.—Extensive cancer involving pylorus, antrum and *pars media* of stomach *AA*, zone of cancerous invasion; *B*, duodenum partly visualized; *C*, portion of stomach still intact. (Original observation by author.)

were demonstrated in 93.8 per cent. of the gastric extracts; abdominal tumor or ridge was palpable in 73 per cent., absent or very low free hydrochloric acid was recorded in 88 per cent.; formol index above 18 in 91 per cent.; Wolff-Junghans' test positive in 82 per cent.; gastric food stagnation exhibited by 76 per cent. and the clinical history was that of primary malignancy or malignancy following dyspepsia of the ulcer type, in nearly 96 per cent. (Figs. 260, 261, 262, 266 and 267).

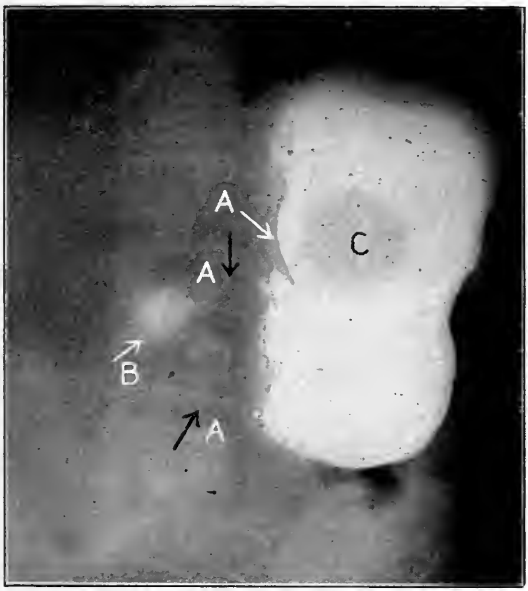


FIG. 265.—Massive cancer involving pylorus, antrum, *pars media* and a portion of the lesser curvature of the stomach. The cancer produces practically complete obstruction. *A, A, A*, zone of cancer; *B*, small barium residue in duodenum; *C*, uninvaded gastric remnant. (Original observation by author.)

Gastroscopy.—In the hands of an expert, the Sussmann gastroscope permits of definite localization of gastric malignancy. It is questionable, however, whether such special procedure is of any great worth in the detection of early malignant changes arising primarily in the stomach wall or developing in the edge of calloused peptic ulcer.

DIAGNOSIS.

In gastric cancer, there are no diagnostic procedures that can take the place of a careful clinical history and thorough, general, physical examination. Dyspepsia in a patient above forty years of age, particularly if the previous history has been ulcer-like, should be considered gastric cancer or potentially cancer until definitely proved otherwise. Terms such as "chronic gastritis," "biliousness," "nervous indigestion," "anemia" and the like should be discarded: such are

descriptive terms for symptoms or parts of disease and not of themselves disease entities. If every clinical laboratory aid is employed *routinely* in the study of dyspepsias and if such aids are interpreted intelligently in the light of clinical history and known pathologic facts, few cases of gastric cancer need go unrecognized and many will be detected before they are surgically hopeless. For the patient's sake, early *exploratory laparotomy* should be urged where the *suspicion* or *possibility* of gastric malignancy exists and when, in spite of rational therapeutic procedures, no progress toward gastric health is being made.

Persistent weight loss by individuals with obstinate dyspepsia should strongly suggest malignancy, especially if the patient is in the fifth decade of life and it is known that his daily food intake and retention have exceeded 2000 calories. Our records show no instance of proved malignancy that has not lost weight previous to laparotomy. Weight gain in gastric cancer (?) has been reported. In such instances the diagnosis is open to question: weight gain may occur in *tumor* of the stomach if such tumor be due to lues, cyst, aneurysm, inflammatory swellings or the tumor be about the stomach; *e. g.*, pyloric lymph-nodes, head of pancreas, etc. Weight loss is more rapid in obstructive cancers than in those permitting free food entrance to and exit from the stomach. This is doubtless due to malignant systemic poisoning and to metastatic growths in extragastric viscera, plus starvation. *Vomiting* accelerates weight decline.

Persistent "occult" blood in the meat-free stool, if associated with weight loss and obstinate dyspepsia, is a valuable hint that a malignant process exists. Constant, positive, chemical tests for blood in the *fasting stomach* contents rarely occur in disease other than malignancy. At times *achylias* associated with severe anemia, Bright's disease, cirrhosis of the liver or circulatory anomalies (varicosities) may be associated with positive, occult blood tests, but in such ailments, the history and clinical examinations differ from those of gastric cancer.

Roentgen studies may early give evidence of a primary intragastric tumor or may disclose calloused ulcer whose diameter exceeds 2 cm. The latter finding is strongly suggestive of malignancy. Obstructive lesions may be demonstrated, but when they can be shown by roentgen studies, the clinical history and test-meal records are usually quite definite proof that gastric deformity will be roentgenologically demonstrated.

Test-meal analyses may return nothing of diagnostic significance other than retention of some part of the physiologic motor-meal. If this evidence of stagnation is associated with low or absent free HCl and the microscopic proof of organisms of the Oppler-Boas group, then the diagnosis of malignancy is practically sure. It should be emphasized again, that in the surgically curable stage of gastric cancer, free HCl may be normal or even increased and Oppler-Boas bacilli absent; in fact, it is extremely uncommon to find such organisms when the free HCl is higher than 15.

Abdominal Tumor is a Sign of Advanced Gastric Cancer.—It should be the aim to make a clinical diagnosis before the disease progresses so far as to produce a mass of sufficient size to enable its palpation through the abdominal wall. Suspiciously palpable ridges, particularly if these move about during respiratory movements or upon inflation of the stomach, should be seriously considered: they usually represent sizable masses when the belly is opened. Patients should be operated promptly when such indefinite ridges are felt and when they persist following lavage of the stomach and emptying the bowels. It is in cases of this type that the highest percentage of surgical successes lie. When an undoubted, abdominal tumor can be detected, satisfactory surgical procedures can be carried out in barely one-third of the patients.

Abdominal tumors lying above the navel are, in more than 90 per cent. of instances, connected with the stomach. They are usually primary in the stomach and in 95 out of every 100 cases where they are so connected they represent gastric carcinoma or sarcoma. A *fixed tumor* does not contraindicate surgery, but better prognosis is possible when it can be demonstrated that the epigastric mass is freely movable. Epigastric tumors likely to be confused with such arising in the stomach are those of the gall-bladder and liver, the pancreas (cyst, cancer or chronic pancreatitis), omentum, retroperitoneal tissues, abdominal aneurysm, right kidney, spleen, colon and, occasionally, foreign bodies. Routine history taking and clinical laboratory examinations usually differentiate these from gastric neoplasms, but there crop up cases where even the experts disagree and exploratory laparotomy must tell the true story.

Lymph-node metastases should be routinely searched for when cancer of the stomach is suspected. The finding of such is of especial significance in cases where no abdominal ridge or mass can be felt and where extensive study, particularly by means of the roentgen ray, is not possible. Lymphatic metastases not only aid in establishing the proof of a malignant condition but the finding of them determines prognosis. In no case where metastases are proved, is it possible to cure the local gastric fault by surgery. It is thus seen that metastases furnish *signs of inoperability* in gastric cancer. Commonly such are: Evidence of gland enlargement above the left clavicle; glands in the rectovesical space ("Blumer's shelf"); umbilical fixation and thickening; local or general increase in the size of the liver; the presence of free abdominal fluid; enlargement of the inguinal lymph nodes; palpable perigastric (peripyloric, usually) glands; mediastinal or lung invasion and extensive size and fixation of the gastric tumor itself.

Grave anemias ("pernicious" anemia, chronic septic anemia, splenic anemia, Banti's disease, leukemia) may simulate gastric cancer. Roentgen examination, test meal analyses and scrutiny of the stained blood smear usually reveal the nature of the ailment, if time be taken to carry out these examinations.

DIFFERENTIATION OF GASTRIC CANCER OF BODY OR FUNDUS FROM TUMORS IN ADJACENT STRUCTURES.

(FROM SMITHIES AND OCHSNER'S "CANCER OF THE STOMACH.")

Signs and symptoms.	Nature of the disease.					
	Gastric cancer (body or fundus).	Tumor of liver.	Tumor of pancreas.	Tumor of colon.	Tumor of kidney.	Retroperitoneal tumor.
Age	45+	40+	Variable	40+	35+	Variable
Sex	Males	Variable	Women ?	Males ?	Males ?	Variable.
Onset	Previous ulcer history or primary progressive dyspepsia	Gradual and progressive	Gradual and progressive; trauma ?	Gradual and progressive or acute with obstruction	Gradual; may have early hematuria	Gradual and progressive.
Pain	In 95 per cent.	Indefinite	Rarely marked	Intermittent, usually may be constant	Indefinite, sometimes colicky	Indefinite.
Vomiting	Common and progressive	Irregular, may occur from pressure	Irregular, may occur from pressure	Rarely early	Infrequent	Irregular, may occur from pressure.
Weight loss	Constant and progressive	Progressive	Irregular	Constant	Constant as a rule	Constant but gradual.
Cachexia	Pronounced	Pronounced late	Variable	May be marked	Often pronounced	Present.
Appetite	Poor	Variable	Variable	Variable	Variable	Variable
Bowels	Constipation the rule	Constipation frequent	Diarrhea not uncommon	Obstipation, later diarrhea	May be normal	May be normal.
Bleeding	Hematemesis or melena 15 to 25 per cent.	Melena at times	Absent	Common, especially late	Absent	Absent as a rule.
Urine	Often negative	Often negative	Often negative	Often negative	Local hematuria in about 50 per cent.	Often negative.

Cystoscopic and pyelogram	Negative	Negative	Negative	Negative	Blood or pus from one ureter; deformed pelvis of kidney on colloidal silver injection	Negative.
Test meal	Low or absent free HCl; 12-hour retention; Oppler-Boas bacilli; lactic acid; altered blood; Wolff test 80 per cent.	HCl may be absent; 12-hour retention variable; Wolff test 30 to 50 per cent.	HCl low or normal; 12-hour retention variable; Oppler-Boas bacilli; lactic acid altered blood rare	HCl usually low; infrequent 12-hour retention, lactic acid; altered blood or Oppler-Boas bacilli	HCl often low; 12-hour retention, lactic acid altered blood; Oppler-Boas bacilli absent	HCl usually low; 12-hour retention lactic acid, altered blood, Oppler-Boas bacilli infrequent.
Stool	Altered blood 89 per cent.	Altered blood uncommon	Altered blood uncommon	Altered blood in 70 to 90 per cent.	Altered blood rare	Altered blood rare.
Abdominal tumor	In about 70 per cent.	From 60 to 90 per cent.; moves with respiration	In about 50 per cent. moves with respiration or with stomach	30 to 50 per cent., moves on respiration or on colon inflation	In 75 per cent.; may move on respiration	70 to 90 per cent.; usually fixed.
Radiogram	12-hour retention not uncommon; gastric filling defects	12-hour retention uncommon; palpation on fluoroscopic examination shows tumor extra gastric	12-hour retention variable; fluoroscopy shows extragastric tumor	12-hour retention uncommon; tumor mass extragastric; obstruction to opaque meal and filling defect of bowel	12-hour stomach retention variable. Fluoroscopy shows extragastric tumor	12-hour stomach retention variable. Fluoroscopy shows extragastric tumor.
Ascites	Commonly occurs late	May occur early	Uncommon; sometimes chylous ascites	Very uncommon	Very uncommon	May occur early.
Jaundice	Late, due to metastases	May be early and constant	Variable accordingly as gall-ducts are obstructed	Rare	Rare	Infrequent.

MALIGNANT PYLORIC STENOSIS AND ITS DIFFERENTIAL DIAGNOSIS.

(FROM SMITHIES AND OCHSNER'S "CANCER OF THE STOMACH.")

Clinical symptoms and signs.	Nature of the disease.				
	Carcinoma.	Peptic ulcer (gastric or duodenal).	Peripyloric adhesions.	Gastric atony.	Extragastric tumor pressing on pylorus (liver, pancreas).
Average age	45+	40 to 50	40 to 50	Often young adult	50
Sex	Males	Males	Females	Females	Females ?
Onset	Often previous ulcer type; dyspepsia, may be continuous and progressive	Intermittent dyspepsia of ulcer type	Cholecystitis, gall-stones colics, jaundice	Gradual	Progressive.
Pain	Early, usually on empty stomach; late, constant	1 to 5 hours p. c.	Worse soon p. c. or irregularly	On full stomach	Irregular.
Vomiting	Daily. Often retention-vomit of rancid type	Frequent. Often retention type; yeasty odor	Frequent. May show retention	Irregular, sometimes retention type, sour or yeasty	Irregular, retention type often, odor yeasty or sour.
Hematemesis or melena	In from 15 to 25 per cent.	In from 20 to 40 per cent.	Rare	Absent	Rare.
Weight loss	Pronounced	May be intermittent	May be slight	Intermittent	May be marked.
Test-meal	12-hour retention; low or absent free HCl; lactic acid; altered blood; increased soluble albumin; Oppler-Boas bacilli; mitotic cells (?)	12-hour retention; free HCl averages 40; altered blood variable; yeasts and sarcinæ may be abundant	12-hour retention variable; free HCl may be normal; yeasts and sarcinæ may be present	Intermittent 12-hour retention; HCl usually present; yeasts and sarcinæ may be present	12-hour retention often present; free HCl may be absent; lactic acid may be present; Oppler-Boas bacilli uncommon; altered blood rare.
Stool	Altered blood in 89 per cent.; Oppler-Boas bacilli 90 per cent. late stage	Intermittent presence of altered blood, yeasts and sarcinæ	Altered blood rare	Altered blood absent	Altered blood variable.
Tumor	In 65 to 75 per cent.	Infrequent	Infrequent	Absent	May be present.
Radiogram	Gastric filling defect; 6-hour retention	6-hour retention; may be crater ulcer, constriction or irregular pyloric outline; dilated stomach	Malformed bulbus duodeni; 6-hour retention; may be irregular pylorus; dilated stomach	Dilated stomach; poor peristalsis; 6-hour retention variable	6-hour retention variable; may be filling defect at pylorus but this may be shown to be extragastric on palpation.
Metastases	The rule	Absent	Absent	Absent	May occur.

Gall-bladder disease in the aged, may simulate gastric cancer, particularly if inflammatory or malignant involvement of the peripyloric nodes produces disturbance in gastric emptying. The early history of the affection should be gone into: there is rarely ulcer-like dyspepsia; the early ailments have not rarely followed typhoid fever, chronic nose and throat disorders, pregnancy, dysentery, malaria, etc., and the presenting disease may have been associated with early jaundice. One-third such cases give histories of stone colics and icterus. The roentgen study, analysis of gastric extracts and stools give valuable information toward excluding a primary stomach disease.

Cancer of the pancreas, unless it be secondary to ulcer or cancer of the stomach, and malignancy of the gall-tract or retroperitoneal tissues is comparatively rare. Primary cancer of the pancreas, lues, cyst or stone may be difficult of detection unless very careful examination be made. Functional tests upon the stool may disclose early diminution or absence of the specific pancreatic ferments.

Tumors of the kidney, large bowel, omentum, abdominal lymph-nodes or small intestine, not infrequently offer problems in exclusion. Their rarity and their atypic situation combined with a clinical history, not primarily dyspeptic, aid in segregating them.

Achylia gastrica is a condition of absent gastric secretion associated with many toxic, infectious and malignant maladies. Formerly, when it was deemed necessary to have absent free HCl in stomach extracts before a diagnosis of gastric cancer was considered, achylia gastrica almost approached the dignity of a disease *sui generis.* Carefully taken history, physical examination and laboratory analyses now readily differentiate the achylias that are benign from those in association with malignant disease of the stomach itself.

Lues, gastric granulomata and *tuberculosis* sometimes exhibit clinical pictures of malignant disease especially if associated with tumor formation. Serologic tests, tuberculin injections, roentgen studies and, in some instances, microscopic examination of extirpated tissue are necessary before the true nature of the affection is known. These ailments are not associated with metastases, even though the primary gastric mass may be extensive. This fact is of great service in proving their non-malignancy.

Foreign bodies in the stomach, ("hair-ball," spoons, knives, etc.) may simulate gastric cancer if they have caused malnutrition by starvation. Their detection is commonly prompt upon roentgen examination.

Chronic constipation, protozoic dysenteries, and drug taking sometimes result in weight loss, cachexia, vomiting and anemia. Instances occur where it requires great ingenuity and skill to prove the absence of malignant disease.

Complications.—In instances of the disease that are operated upon early, few of the commonly described text-book complications are met with.

Pyloric Obstruction.—Pyloric obstruction occurred in some grade of nearly 72 per cent. of our cases. Gastric stagnation may be enormous, the stomach holding many quarts.

Obstruction at the Cardia.—Obstruction at the cardia occurred in 1.8 per cent. Dysphagia, vomiting soon after food ingestion, rapid emaciation, scanty urine, constipation with roentgen proof of obstruction usually establish the diagnosis.

Malignant "Hour-glass".—Malignant "hour-glass" occurs in approximately 1 out of 15 cases of the disease. It is graphically demonstrated by fluoroscopy and roentgenograms.

Gross Hemorrhage.—Gross hemorrhage occurred in nearly 19 per cent. of cases. Copious bleeding is more common in those gastric cancers which have had a long "precarcinomatous" history of dyspepsia (ulcer?) than it is in cases where a rapidly developing neoplasm has arisen in an individual previously sound, gastrically. Fatal hemorrhage occurs in rather more than 5 per cent. of instances.

Perforation.—Perforation of gastric cancer is usually fatal, but instances where well localized perigastric abscess develops are by no means uncommon. Perforation is a complication of from 2.5 per cent. to 6 per cent. of instances, depending upon the stage of growth, situation and histologic type of tumor.

Fistula.—Fistula complicates perforation. The communication is commonly to the large bowel, gall-bladder, liver, pancreas or to the lesser peritoneal sac. Gastro-colic fistulæ occur in nearly 2 per cent. of all late gastric cancers. Fecal vomiting, lienteric diarrhea, gross hemorrhage or the speedy appearance of red-colored stools following the administration of a carmine capsule suggest the diagnosis. The roentgenograms prove the existence, size and direction of the fistulous tract.

Jaundice.—Jaundice occurs in about 3 per cent. of the early gastric cancers and in more than 12 per cent. of instances where the disease is advanced. Direct extension to the gall-tract or liver or pressure upon the bile ducts is commonly responsible for the icterus. In some cases metastases to the peripyloric nodes produce jaundice as a consequence of common bile-duct obstruction. The head of the pancreas may be invaded with similar consequences.

Thrombosis.—Thrombosis is infrequent. It usually occurs as a terminal event. The femoral, saphenous, external iliacs, subclavian and brachial are the vessels commonly involved.

Enteritis.—Enteritis may early complicate gastric cancer and be particularly exhausting. It is commonly manifested by abdominal pain and diarrhea. Such symptoms may represent the earliest manifestation of gastric malignancy. When they appear in a chronic dyspeptic or in any individual beyond the fifth decade of life, careful examination of the stomach should invariably be made.

DUODENAL ULCER.

Definition.—A form of dyspepsia, usually chronic in course, and occurring intermittently, associated with local loss of the tissues forming the wall of the duodenum.

Incidence.—Until within the last decade, it was thought that the lesion was relatively uncommon. Surgical explorations made for the relief of chronic dyspepsias have revealed the true frequency of the affection. Study of 8341 cases of chronic dyspepsia made by the writer, indicates that there were 1257 operatively demonstrated instances of duodenal ulcer (15.1 per cent.). In this group, there were 513 cases of gastric ulcer (6.1 per cent.). These figures indicate that of peptic ulcers, duodenal ulcer is operatively demonstrated nearly two and a half times as frequently as is gastric ulcer. Graham's statistics return a similar ratio: Of 1751 cases of peptic ulcer, this investigator had operatively proved 1300 instances where the lesion was duodenal and 451 where the ulcer was on the gastric side of the pyloric vein.

Age.—Moynihan records 31 cases of duodenal ulcer of the hemorrhagic type occurring in children below the age of four years. In 28 instances the patients were less than eight months old. Several fatal terminations took place within a few hours following birth. The clinical picture was that commonly associated with *melena neonatorum.*

Commonly the affection is exhibited in adult life. Instances are most frequent in the fourth and fifth decades. In Moynihan's series of 115 cases, 58 patients were between the ages of thirty to fifty-one years. In the writer's study of 1257 cases, the average age was just over forty-six, and approximately 61 per cent of patients were between thirty and sixty years.

Sex.—Males are much more commonly affected than are females. This fact has been abundantly shown by the observations of Graham, W. J. Mayo, Moynihan and others. In the writer's series of operatively demonstrated cases, there were more than four and one half times as many males as females. In Moynihan's group the sex ratio was that of six males to one female.

Race.—The Caucasian family appear to be peculiarly prone to duodenal ulcer. It furnishes the bulk of cases at any busy clinic. Doubtless the future will disclose that other races are more commonly affected than is at present thought, when surgery among such becomes general. *Heredity* appears to play only a relatively small part in duodenal ulcer incidence. While occasionally a family is met with in which the disease has appeared through several generations, yet apart from the families with hemophiliac or luetic taint, it would seem that the transmission of modes and habits of life can explain the family appearance of the ailment.

Previous Diseases.—In more than 56 per cent. of the patients studied by the writer, a history of frequently recurring infectious disease was noted (tonsillitis, la grippe, head sinus affections, etc.) or the patients dated the beginning of their dyspepsias from an acute exanthematous

or septic ailment. Seasonal occurrence of symptoms was recorded in nearly 40 per cent.—Spring and Fall being favorites. When it is recalled that during these seasons acute infectious diseases are widespread and are frequently inadequately treated, the relationship of microörganisms to the production of duodenal ulcer or toward reëstablishing bacterial activity in tissues already damaged seems worthy of more than casual note. The experimental studies of Rosenow upon the production of ulcer by repeated injection of streptoccoci lend a certain amount of support to such view.

Concomitant disease of the gall-bladder or the appendix, or both, is frequent in duodenal ulcer. It occurred in nearly 50 per cent. of the writer's cases. The clinical histories indicate that, not uncommonly, ailments of these portions of the digestive apparatus preceded the onset of damage in the duodenum. The researches of Hamburger upon experimental pyloric spasm with respect to the production of peptic ulcer would appear to emphasize the importance of affections of the appendix or the gall-bladder in the production of duodenal ulcer. It is well known that on account of the embryologic relationship between the pylorus, the appendix and the gall-bladder, disease in the two latter may produce marked pyloric spasm, through vagus and sympathetic irritation. Such prolonged and intermittently active spasms are quite capable of bringing about disturbances in circulation and peristalsis in both the stomach and the duodenum, with probably resultant ulceration. It would also appear that the presence of infection in either gall-bladder or appendix over long periods is a not unimportant factor in the spread of microörganisms to the duodenal lining, through the abdominal, freely interconnecting lymph-channels. If damage has already been done to the duodenal wall as a consequence of circulatory upsets, traumata, etc., such microörganisms may lodge, multiply, and be a factor in the causation of ulcer. The ulceration may be of extremely rapid development, and of the fatally bleeding type, should the invading bacteria be of the hemolytic variety.

General tuberculosis is occasionally associated with duodenal ulcer. Some 40 cases have been tabulated by Moynihan. However, ulceration of primarily tuberculous origin is rare in the duodenum. About a dozen instances have been described. Moynihan mentions 2 cases, and states that in three other patients suspicion of the ailment's being tuberculous was entertained.

Ulceration of the duodenum in association with burns has been frequently commented upon. Perry and Shay state that of patients dying as a consequence of severe burns or scalds, in 3.3 per cent. duodenal lesions were demonstrable. In the study of a group of patients dying from other ailments, these writers found duodenal ulcer present in but 0.4 per cent. Ulcers of the duodenum in association with cutaneous burns or scalds are apparently the result of congestion of the capillaries in the duodenal mucosa, as a consequence of toxic products or from minute emboli. The erosions resulting, as necrosis takes place, are aggravated by the peptic activity of the gastric juice and the tryptic power of the pancreatic secretions and bile.

Uremia, grave anemias, cardiac lesions, toxins (the result of disordered metabolism or of chemical changes foreign to the human economy), local trauma to the duodenal lining from improper food or from foreign bodies, or abdominal traumata, are not rarely factors in the production of duodenal ulcer. It is doubtful if alterations in the chemistry of either the gastric or the pancreatic juice are, of themselves, capable of causing duodenal ulcer, until local loss of epithelial lining has previously been brought about through other agents. This loss need be but small, and quite incapable, of itself, of producing signs or symptoms.

Habits.—Duodenal ulcer commonly occurs in full-blooded, sturdily-built people. Frequently, these give a long history of careless living and of dietetic and hygienic irregularities. But this is by no means the rule: leading a model life does not appear to confer immunity to the disease. History of the excessive use of alcohol and tobacco is not rarely obtained. Many patients have, however, been abstainers from these drugs. Moreover, alcohol and tobacco are so universally used, that, were such the sole or an important factor in the production of duodenal ulcer, the affection would be of much more common incidence. In such event, also, most females and children would be practically immune.

Morbid Anatomy.—Superficial erosions of the duodenum may be recognized with difficulty, even when the gut is spread out. Occasionally, areas of congestion may be recognized, and if these are minutely scrutinized, fissures and shallow surface-ulcers may be seen. The latter resemble the herpetic spots which are sometimes seen on the tongue or inside the cheek. From the serous side of the duodenum, there may be no evidence of such ulcers, either to sight or to touch.

Acute bleeding ulcers may be recognized as local areas of multiple, punctate hemorrhage on which small clots or blood pigment may be noted. If the ulceration be associated with hemolytic cocci, then local points of hemorrhage may be seen in the submucosa, and occasionally in the subserosa.

Duodenal ulcers that have for years been associated with chronic intermittent dyspepsia are practically always associated with such a highly developed scar-tissue limiting-zone as to be readily visible and palpable when the gut is exposed at laparotomy or at autopsy. More than nine out of ten such ulcers are located in the first two inches of the duodenum beyond the pyloric vein (Mayo's vein), and the ulceration is most commonly on the anterior-superior wall of the gut. In shape the ulcer may be round, oval or somewhat stellate. The serous membrane covering it is pearly gray and shiny at the center, becoming white or yellowish toward the periphery. Through the serosa may be seen dot-like areas of congestion or hemorrhage. The limiting margin of the ulcer is commonly thickened, and may be corrugated and highly vascularized. The area of the duodenum immediately adjacent to the ulcer is usually more vascular than is the remainder of the gut. On palpation, these ulcers have a disc-like feel. They often feel larger than they appear. Where there has been considerable chronicity, the

examining finger may detect a definite crater when the luminal aspect of the ulcer is explored. The ulcers vary greatly in size. Some are barely the size of the head of a lead pencil; others may be as large as the palm of one's hand. The larger ulcers are commonly on the anterior wall of the intestine; such is, however, rarely the site of as deep craters as are those on the posterior wall of the bowel. This fact has been emphasized by W. J. Mayo.

In instances where ulcers have been particularly active, deformity of the duodenum may be extensive. Contraction of the scar-tissue may bring about hour-glass duodenum, local out-pouchings, resembling diverticula, or inward bulgings, with puckering, angulation or stenosis of the intestine. Extension of the ulcer to the pylorus, may be followed by malignant transition of the ulcer at its pyloric edge. If perforation takes place, a clean-cut, punched-out orifice may represent the ulcer base. Commonly, perforation has been protected. In this event, strings or tags of omentum may be glued to the serous base of the ulcer, or a mass of adhesions may fix the ulcer firmly to adjacent viscera (liver, gall-bladder, large intestine, pancreas) or to the omentum, great vessels or anterior abdominal wall. Perforation may occur in spite of massive adhesions. When this happens, fistulous tracts, with or without abscess or fatal hemorrhage, are established.

Chronic, calloused duodenal ulcers viewed from the lumen of the gut, vary greatly, accordingly as they are discovered in activity or quiescence. If there has been a recent exacerbation of the ailment, then a crater ulcer, with thickened, ragged, sometimes overhanging or terraced, puckered margins may be seen. The margins may be very vascular and bleed easily. The base is generally clean. About the ulcer there commonly exists a zone of congestion, in which swollen bloodvessels are usually visible. If the duodenal ulcer is definitely quiescent, then it appears as a shallow crater (especially anterior wall ulcer), pale, shiny, and with irregular, smooth margin, overhanging or ridged. The periphery of the ulcer scar is commonly well delimited, and about it the duodenal wall may be thickened and congested.

Ulcer of the duodenum is commonly solitary. Multiple lesions are however, not of sufficient rarity as to be curiosities. In all operative explorations, the entire gut should be investigated for multiple ulcers, even though one is readily discovered and may seemingly account for all the symptoms of the case in hand. Unless this routine is carried out, operative procedures may fail to give the desired or expected relief.

Secondary Effects of Duodenal Ulcer.—*Carcinomatous transformation* is exceedingly rare. It occurs about 6 times in 1000 cases. Extension of the ulcer to the pylorus may result in malignant change at the pyloric margin of the ulcer. This is by no means rare, and furnishes an argument for those who believe that, whenever possible, duodenal ulcers should be excised.

Stenosis of the duodenum or of the *pyloric exit* is the most common secondary effect of the presence of chronic, calloused, duodenal ulcer. It may vary from slight stenosis, associated with more or less pronounced spasm, to practical closure of the duodenal or pyloric lumina.

The stomach is then commonly dilated, and its muscle layers may be atonic.

Perforation, if acute and unprotected, may result in general and fatal peritonitis or, if adjacent viscera are entered, in *fistula or abscess*. In the latter event, grave damage generally results to the invaded viscus. If perforation involves one of the great vessels (abdominal aorta, portal vein, renal artery, etc.) sudden fatal termination as a result of hemorrhage may be expected.

Anemia of the secondary type usually occurs and persists where hemorrhage from the ulcer is copious or when small, frequent hemorrhages take place. Malnutrition may be an associated complication.

Symptoms.—From 3 to 5 per cent. of duodenal ulcers give no evidences of their existence. They are usually discovered at laparotomy for other ailments or are found at postmortem examination of patients dying from accident or extra-duodenal disease. Commonly, however, duodenal ulcer manifests itself either by an acute crisis (hemorrhage, perforation) or by chronic dyspepsia.

THE ACUTE CRISIS.—*Hemorrhage.*—This may come on suddenly without evident, causative factor. In other instances, there is a history of cutaneous burn, operative procedure, external trauma, physical stress, swallowing of poisons or foreign bodies, an acute infectious ailment or of indiscretion in eating or drinking. Hematemesis may be copious and exhausting, or signs of hemorrhage into the bowel, with the passage of dark stools shortly apparent. Pallor, shock, collapse and death may quickly follow. Pain, often agonizing in character, occurs in many of the cases, particularly if perforation of the gut accompanies hemorrhage. Signs of peritonitis, local or general, supervene.

Perforation.—Perforation is perhaps the most serious event in the course of duodenal ulcer, even though protection is afforded by omentum or neighboring viscera. The onset is commonly sudden. The chief clinical manifestation is *pain.* This may be so pronounced as to render the patient uncontrollable. It is evidenced by distressed cries, doubled-up posture, protective pressure of the hands over the epigastrium, dyspnea, drops of sweat upon the contracted brow, cold, pale skin, subnormal temperature, and rapid pulse. If prompt relief is not at hand, peritonitis quickly develops. The temperature rises, the abdomen becomes fixed and distended, the pulse small and thready, delirium follows and death ensues.

Protected perforation may be initiated in a manner similar to unprotected, fatal perforation. After the initial shock, symptoms subside, and although abdominal tenderness, vomiting, pain, and dyspepsia remain, the patient ultimately recovers fair health, lingers until relieved by operative procedures or he succumbs to disturbances in function in the organs that have acted as temporary protection against perforation into the peritoneal sac.

CHRONIC, CALLOUSED DUODENAL ULCER.—This presents a symptomatology of such characteristic type as to permit a positive diagnosis being made, in fully seven out of ten instances, from the clinical history. The essential feature of the affection is a chronic dyspepsia, commonly

occurring intermittently, in adult males. The prime points typifying this dyspepsia are:

(*a*) *Periodicity of Complaint.*—In non-stenosing or otherwise uncomplicated duodenal ulcer, the *intermittent* appearance of dyspeptic storms is striking and of great diagnostic value. This peculiar periodicity was noted in 82 per cent. of our duodenal ulcers of the uncomplicated variety. The "attacks" correspond to recrudescences of activity in the ulcer, its extension or the formation of new ulcers. They may hint at the onset of complications (hemorrhage, perforation, or malignant change) in those chronically suffering. This is especially true in such instances where attacks or "spells" come on with but short dyspepsia-free intervals.

The duodenal ulcer patient is commonly comfortable between attacks so long as the ulcer remains uncomplicated. In the latter instance, the affection manifests itself by a continuous digestive upset.

(*b*) *Epigastric Pain or Distress.*—Epigastric pain or distress is experienced by about 96 per cent. of patients. It varies in character from vague discomfort to prostration, gnawing or colics. The severe attacks of pain very commonly presage hemorrhage or perforation. They may, however, be only indications of pronounced pyloric, duodenal or gastric spasms. In such cases, the colicky attacks may punctuate a more or less constant sensation of epigastric "burning."

The distress in duodenal ulcer is commonly most intense at or to the right of the midline and above the navel. There may, however, be general epigastric or abdominal discomfort. In ptotic females the distress may be located far below the navel.

A point of subjective maximum intensity of pain is usually recorded. It may have comparatively little relationship to the actual anatomic situation of the duodenum and it may in no wise correspond to areas of tenderness delimited upon abdominal palpation. The local, subjective pain point is in the right upper abdominal quadrant in more than 90 per cent. of instances of duodenal ulcer.

(*c*) *Pain-time.*—Pain-time in duodenal ulcer of the uncomplicated type, bears such striking relation to food ingestion that the phenomenon furnishes a most important point in diagnosis. Fully 85 per cent. of ulcers of the uncomplicated type cause pain within two to five hours following the taking of a meal. Commonly, the more bulky the meal, the greater the time-interval elapsing before the appearance of pain. While in many cases of duodenal ulcer, some discomfort appears soon after eating, the distress does not amount to actual pain until four hours *post cibo*. Pain appearing regularly at night is experienced by about 17 per cent. of cases.

With exception of the acute pain crises associated with hemorrhage or perforation, the pain of duodenal ulcer is apparently due, in the main, to exaggerated peristaltic movements of the stomach and of the duodenum itself, as a consequence of local, neuromuscular irritation. This local irritation may be in part due to the forceful injection of gastric contents rich in HCl and pepsin, into the first part of the duodenum (the seat of the great majority of duodenal ulcers), but that this is not the only factor concerned with pain production is abundantly demonstrated by

the recent studies of Rehfuss and Carlson and Hamburger. These investigators have demonstrated that at the time that peptic ulcer pain is most pronounced, the HCl and pepsin content of the gastric juice is by no means at the maximum. However, at the time of maximum pain intensity, intragastric (and probably intraduodenal) pressure is at its highest point and muscular contractions most marked.

(*d*) *"Food-ease" of Pain.*—"Food-ease" of pain in duodenal ulcer is of diagnostic importance in nearly 80 per cent. of uncomplicated duodenal ulcers. The pain may be most annoying just before the time that patients are ordinarily accustomed to eat, or it may awake them at night, between midnight and 2 A.M. Eating or drinking usually produces entire amelioration of symptoms. A large meal brings about longer relief than does a small one. Relief by alkalies, lavage, vomiting, a drink of spirits, an orange, or by posture is quite common. The mechanism of relief, hence, does not appear to be explained wholly by the theory that neutralization of the acid of gastric or duodenal contents is brought about by the above measures: numerous agents capable of causing relief of pain are not alkaline nor do they empty the stomach or duodenum and thereby remove an offending gastric or duodenal content. It would seem that the chief factors concerned in pain relief in duodenal ulcer are those connected with counteracting abnormal peristaltic or muscular activity of the stomach and duodenum, with the resultant diminution of intragastric and intraduodenal pressure.

"Food-ease" of pain is so constantly manifested in duodenal ulcer of the uncomplicated variety, that its constant exhibition in "spells" of dyspepsia, attack after attack, is almost pathognomonic. It assuredly indicates peptic ulcer, and most commonly the ulcer is duodenal or pyloric, particularly if the chronic dyspeptic is an adult male.

(*e*) *Vomiting.*—Vomiting is recorded in practically eight out of ten instances of duodenal ulcer of all classes, and in about 6 out of 10 cases where theulcer is uncomplicated. Vomiting generally comes on at the height of the gastric distress, *i. e.*, when duodenal and gastric spasm and peristalsis are at their maximum intensity. The vomitus is commonly composed of acid fluid intermixed with mucus or food or stained with bile. In stenosis cases, food that has lain in the stomach for longer than eight hours ("delayed vomit") may be constantly vomited if the patient is on diet of ordinary bulk. Sometimes, where there is much dilatation of the stomach with atony, the vomitus is particularly copious and may contain food eaten so long before that it requires an effort on the part of the patient to recall when certain vomited materials were taken.

(*f*) *Pyrosis, Waterbrash, Eructations* and *Belching of Sour Gas* are distressing accompaniments of the dyspeptic attacks in more than 70 per cent. of uncomplicated duodenal ulcers. When stenoses, with gastric retention have become established, these symptoms may be constant and annoying.

(*g*) *Gross Hemorrhage* (*Melena and Hematemesis*).—Gross hemorrhage was recorded in 33 per cent. of the writer's series. Melena was noted nearly three times as frequently as was hematemesis, but there were instances where melena had not been observed, but the vomiting

of blood had been very copious. It is evident from the above named incidence of gross hemorrhage, that at least twice as many cases of duodenal ulcer must be diagnosed without history of melena or hematemesis, as with it. Given an ulcer symptom-complex, however, the occurrence of melena or hematemesis clinches the diagnosis in 95 per cent. of instances.

"Occult hemorrhage," *i. e.*, the chemical demonstration of altered blood, was recorded in 40 per cent. of properly prepared stools, at some time in the course of the affection, of those duodenal ulcers so tested. It is evident that one must not delay the diagnosis of duodenal ulcer until the stools return positive chemical tests for blood-pigment.

(*h*) *Weakness.*—Weakness is experienced by the majority of duodenal ulcer patients during their attacks of dyspepsia. It is commonly due to partial starvation, pain with loss of sleep and rest, exhausting vomiting, hemorrhage with anemia, and to free administration of opiates. In the dyspepsia-free intervals of uncomplicated ulcer strength is commonly regained rapidly. In duodenal ulcer associated with stenoses, perforation or frequent hemorrhage or constant seeping of blood, weakness may be constant and progressive. Exhaustion may cause death.

(*i*) *Constipation.*—Constipation, particularly shortly before or during the period of indigestion, is noted in more than 55 per cent. of duodenal ulcer cases. Between the attacks, the bowels may move normally. In stenosis cases, constipation is likely to be obstinate as a consequence of reduction in the quantity of food that passes out of the stomach.

(*j*) *Appetite.*—Except in the dyspeptic periods, food desire is well maintained in the majority of instances of the affection. Many patients develop a "poor-appetite habit" as a consequence of dread of precipitating pain, vomiting or hemorrhage by normal eating. During the attacks, food desire is usually reduced. In stenosis cases, appetite is generally poor, inasmuch as nausea may be frequent or constant.

Signs of Duodenal Ulcer.—(*a*) *Physical.*—Except in the complicated cases, duodenal ulcer patients are commonly well nourished and frequently of the full-blooded type. The physical appearance may be much altered as a result of limited diet, pain, loss of sleep, hemorrhage, stenoses or perforation. In such events, malnutrition may be marked and anemia pronounced. However, even the desperate cases rarely present more than a picture of starvation and exhaustion. This is only exceptionally complicated by such indications of toxic cachexia as are common in malignant disease.

Weight loss is apt to be constant during the attacks of dyspepsia. In some instances it amounts to but a few pounds; in others fifteen to sixty pounds may be lost within a few weeks. In the dyspepsia-free interval, weight is generally gained rapidly. Where stenoses, perforation or hemorrhage have occurred, weight loss may be constant and alarming. Malignant change in the edge of an ulcer that encroaches upon the pylorus may result in progressive decrease in weight and constantly maintained dyspepsia. The average weight loss in the writer's series of duodenal ulcers was 17.3 pounds.

Anemia of a mild degree and of the secondary type is common in all duodenal ulcers that have become chronic. It is not the rule, however, since numerous cases appear where there is plethora instead of anemia. After severe gross hemorrhages or as a consequence of constant seepage of blood, the prognosis may be grave. Nucleated red cells may be present in the stained smear. In the uncomplicated duodenal ulcers forming the writer's series, the hemoglobin averaged 75 to 80 per cent. In the complicated cases (stenoses, perforations, malignant change) the hemoglobin averaged 60 to 65 per cent.).

(*b*) *Abdominal Tenderness.*—There is commonly present an area of tenderness to palpation. It usually lies to the right of the midline. It corresponds to the anatomic position of the first third of the duodenum and the terminal fifth of the stomach. Areas of tenderness are rarely outside the limitations of the right upper abdominal quadrant. In about 60 per cent. of instances of duodenal ulcer, points of maximum tenderness in zones that are the location of rather widespread palpatory discomfort can be determined. As has been pointed out by Head, such zones do not necessarily correspond to the situation of the duodenal lesion. Ulcers that have extended so as to involve the peritoneum are the most sensitive to pressure. Where there has been acute extension, points of exquisite tenderness can be noted. Tumor-like epigastric ridges, usually not movable, are exhibited in about 4 per cent. of duodenal ulcers where there has been chronic, protected perforation, or extension of inflammation to adjacent viscera. Quite commonly, right upper abdominal quadrant tenderness is not due to duodenal ulcer, even though such may be present, but is caused by an inflamed or distended gall-bladder, gall-stones or pyloric spasm associated with such ailments or occurring in connection with lesion of the appendix. Duodenitis, not complicated with ulcer formation, may give rise to not only abdominal tender areas but also to clinical syndromes closely simulating ulcer.

(*c*) *Dilated Splashy Stomach.*—Dilated, splashy stomach, with or without "visible peristalsis" may be demonstrated where there is persistent pyloric spasm or pyloric obstruction of high grade, should the subject be not too fat. Visible peristalsis was noted in 8 per cent. of the instances of pronounced pyloric or duodenal stenosis in the writer's series.

Information Returned by Laboratory Examinations.—TEST-MEAL.—Apart from the observations connected with disturbances in gastric or duodenal emptying rate, common test-meal data may be of but little value toward the establishment of a diagnosis of duodenal ulcer. Certainly, contrary to generally printed text-book statements, one cannot depend upon the finding of so-called "hyperacidity" or "hypersecretion," in the majority of cases of uncomplicated peptic ulcer. The secretory test-meal data may closely simulate the findings in simple duodenitis, gastritis, pyloric spasm associated ailments of the appendix of gall-bladder, or of simple gastric ulcer.

The average free HCl in the writer's series was 49. There were wide variations. In nearly 2 per cent. of cases free HCl was absent. The highest free HCl estimation was 190. Stomach contents removed after

a full, mixed meal has been undergoing digestion for several hours, generally return acid estimations that are higher than when the acidity is tested after the administration of so bland a meal as the Ewald or the Dock breakfast. If the stomach is emptied in the morning before food has been given, there is not infrequently more than the normal amount of "fasting" contents (20 to 30 c.c.). It is not unusual to remove as high as 350 c.c. When great quantities of "fasting contents" are *constantly* removed, then laparotomy or fluoroscopic examination generally discloses that such cases are instances of pyloric stenosis, with or without added pyloric spasm, or they are examples of pronounced gastric atony.

Total acidity estimations vary greatly in duodenal ulcer of the simple type. The total acidity is commonly higher than in cases of the similar type of gastric affection. It averaged 70 in the writer's series.

In Complicated Duodenal Ulcer stenosis cases returned average free HCl estimations of 54. The total acidity averaged 78. The highest total acidity was 255. There were 1.2 per cent. in which free HCl was absent. In *acute perforation*, for obvious reasons, acid estimations are commonly not available. In cases of *chronic perforation*, the acid estimations closely approximate the figures returned by similar gastric lesions, this doubtless because stenoses and gastric retention are usually concomitant.

All types of duodenal ulcer require study by the fractional method of analysis devised by Rehfuss. It is more than likely that when a great number of operatively demonstrated instances of the affection have been investigated by this procedure, a better knowledge of the secretory activity of both stomach and duodenum will be obtained.

Duodenal tubes as they are commonly used, return little positive information in instances of duodenal ulcer. This has in the main been emphasized by the studies of Crohn.

Motor Function in Duodenal Ulcer.—This may be tested by the roentgen method or by the administration of a physiological meal of mixed food, bulky in character. (See Part I.) The latter procedure is undoubtedly the better, inasmuch as it reveals the emptying rate of the stomach under physiological conditions. The roentgen motor-meal does not. Certainly it is not the kind of food that the patient is going to subsist on. Another advantage of the physiologic motor test-meal is that it can be administered at frequent intervals for the purpose of testing individual variations or the effects of therapy at very little inconvenience or cost to the patient. The roentgen motor-meal is expensive, disagreeable and the patient frequently has to journey long distances to have the proper observations made.

Some degree of eight- to twelve-hour gastric retention is exhibited in approximately 57 per cent. of all chronic duodenal ulcers. In those cases of stenosis, with or without associated pyloric or duodenal spasm, twelve hour retention of some degree is a constant observation in 88 per cent. The quantity of stagnation contents is subject to wide fluctuations, in groups of patients and in the same patient examined at different times. This is especially noted if the results observed before the administration of an antispasmodic medicine (atropine or bella-

donna) are compared with those noted afterward. In approximately 1 out of 5 cases of the whole group of duodenal ulcers, almost absolute obstruction to the onward progress of food is recorded. Such observations should always be checked up at repeated sessions and particularly after the administration of antispasmodic medicines. This point warrants especial consideration if the test-meal findings of retention are to be taken as guides to the carrying out of surgical procedures.

Blood.—Blood is a variable finding in the test-meal extracts in duodenal ulcer. It occurred in but 17 per cent. of the test meals in the writer's series, when the blood pigment was searched for by the benzidin test. Not rarely, positive "occult" blood tests are returned because of the presence of stagnant food.

Lactic acid is an extremely rare finding in the test-meals of cases of duodenal ulcer. It was present in less than 1 per cent. of extracts examined. It was never recorded in non-retention types of ulcer. In patients that are much emaciated, when gastric extracts return low free HCl estimations and signs of obstruction suggest malignancy, the absence of lactic acid in the gastric contents may be of considerable worth diagnostically. The importance of this statement will be seen when it is recalled that lactic acid is present in more than five out of ten instances of gastric stagnation due to malignancy. Lactic acid is rarely a finding when the free HCl is higher than 15.

Microscopic examination of gastric extracts only yields information of value in the retention group of ulcer. In such cases the presence of a simple fermentation type of stasis, as shown by excess of actively budding yeasts and by clusters of sarcinæ, enable reasonably accurate segregation of instances of benign from those of malignant stenosis.

Stool.—In nearly 62 per cent. of our patients stool analyses contributed nothing of diagnostic value. Recent hemorrhage shows itself by dark or tarry stools for several days following the actual event. Chemically, blood may be proved to exist for some days longer. Perforation of an ulcer to the pancreas may bring about stools deficient in bile pigment or of pancreatic enzymes.

During periods of an ulcer's activity, if the patient is kept upon cereal or milk diet for several days, the stool may contain "occult" blood. It was present in 33+ per cent. of our cases. Progressing ulcers or ulcers undergoing cancerous change generally permit of the *constant* demonstration of blood pigment in the stools. It is in this type of case that the so-called "occult" blood tests have their greatest diagnostic usefulness.

Roentgen Evidences of Duodenal Ulcer.—These are either (*a*) *inferential* or (*b*) *positive.*

(*a*) **Inferential Evidences.**—Such are furnished by uncomplicated duodenal ulcers: *i. e.*, those ulcers which have not perforated, have not formed adhesions to neighboring organs or are not associated with a great amount of deforming callus with the production of stenoses.

Upon *fluoroscopic examination,* there may be demonstrated *intermittent* retention of the opaque motor meal after six hours. In such event, at different *seances* bismuth or barium residues may be present in the stomach in varying quantities. Some examinations may demon-

strate no retention whatever. Retention of the opaque meal in this type of case, commonly results as a consequence of marked duodenal or gastric spasms. The degree of retention is apt to be more constant or pronounced if muscular atony of the stomach has become established.

In the majority of uncomplicated duodenal ulcers six-hour bismuth or barium retention is absent.

The fluoroscopic *observation meal* not rarely demonstrates noticeable pyloric spasm, with delayed visualization of the *bulbus duodeni.* Such instances of spasm are quite regularly associated with remarkably increased *gastric hyperperistalsis* (hypertonicity) provided there does not exist gastrectasia of pronounced degree. The peristaltic unrest of the stomach may be exceedingly noticeable: deep waves, often seeming to divide the stomach into definite loculi, rapidly pass from the fundus toward the pylorus as soon as the opaque mixture enters the stomach. If pyloric spasm is somewhat slow in manifesting itself, then the vigorous peristalsis may propel part of the opaque meal with great force and speed into the duodenum. As a consequence of this hypermotility, part—rarely all—of the bismuth or barium mixture, leaves the stomach very quickly. After pyloric spasm is established, even though the increased peristaltic tone may be maintained, the great bulk of the opaque meal remains in the stomach for a normal period of time or even longer than normally. Occasionally, where the pyloric sphincter remains tightly contracted, peristaltic waves may be seen to pass from the pylorus toward the fundus of the stomach—"reverse peristalsis."

The stomach is not infrequently seen to be enlarged. It is more apt to be of increased size when a period of vigorous gastric peristaltic activity has produced weakening of the stomach wall. Some grade of atony then supervenes and dilated, flabby stomach results.

Fluoroscopically, the *bulbus duodeni* may exhibit no abnormalities, even though active ulceration exists. Commonly, however, the fluoroscope demonstrates changes in contour. These may be manifestations of local or general duodenal spasm. They are sometimes very persistent and readily may be mistaken for actual, gross, pathologic alterations in contour. When changes of this type are present, and when there is no history or other evidence of stenosis or perforation, frequent examinations should be made after the administration of atropin or belladonna, in dose approaching individual tolerance for the drug. Such repeated examinations usually aid in the segregation of instances of mere duodenal spasm from those where actual deformity of the gut has been caused by pathologic processes. As a rule, duodenal spasm in uncomplicated ulcer is transitory. It may disappear of itself. Palpatory massage of the duodenal area during fluoroscopy aids in eliminating spasmodic contractures or shows that such areas are shifting and hence not caused by any persistent, locally deforming disease.

Areas of tenderness over all or part of the duodenum, if taken into consideration with other clinical observations and if persistent after the administration of antispasmodic medicines, are of corroborative value toward proving that ulcer exists. Such areas are not, however, pathognomonic for ulcer: they are readily demonstrated in instances of

duodenitis without ulcer, affections of the gall-tract, irritative lesions of the stomach, disease (usually inflammatory or lithic) of the right kidney, and even in chronic or subacute ailments of the appendix, particularly if such are complicated by excessive HCl secretion or pyloric spasm.

In cases of uncomplicated duodenal ulcer, *plate or film studies* usually add nothing to the fluoroscopic examinations.

(*b*) **Positive Evidences.**—Such occur where the progressive growth of duodenal ulcers and attempts at protective repair have produced various degrees of gross damage to the duodenum or have resulted in the involvement of adjacent viscera. It is really to this group of cases that the value of roentgen ray, as a definite diagnostic procedure toward the proof of ulcer, is limited. Of course, it should be remembered that

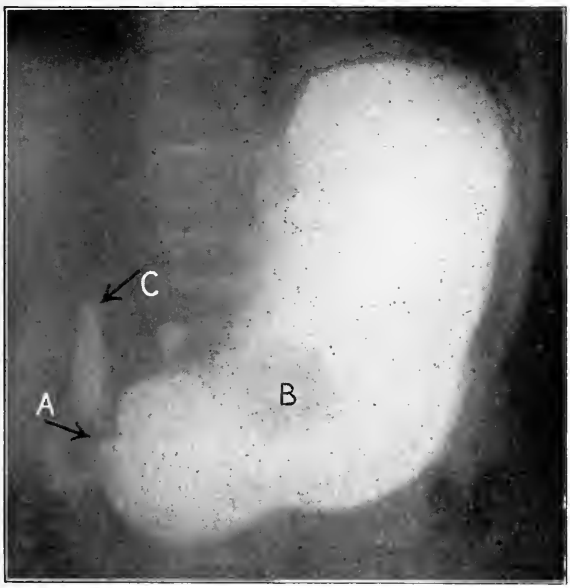


FIG. 266.—Partly obstructing duodenopyloric ulcer (*A*) with marked, secondary dilatation of the stomach (*B*); duodenum adherent to gall-bladder at *C*. (Original observation by author.)

should the roentgen examination not be possible, careful interpretation of history and clinical and laboratory data is generally sufficient to establish a diagnosis approximately correct, even though it may be limited with respect to proof of the actual location and the extent of the disease. Certainly, measures for the relief of the ailment should never be postponed because roentgen examination is not possible (Figs. 267 and 268).

Fluoroscopic examination may demonstrate rather constant six-hour retention of some quantity of the opaque motor meal, when there has occurred stenosis of the duodenal lumen or involvement of the pylorus. This retention may vary in amount, accordingly as the deforming lesion of the duodenum is or is not complicated by pyloric or duodenal spasm. Not rarely, six-hour residue of the roentgen motor meal is at

variance with the demonstration of food retention after a physiologic motor meal has been administered: instances occur where the administration of food that calls forth secretory as well as motor activity of

FIG. 267.—Duodenal ulcer, without pyloric or duodenal stenosis, involving second portion of duodenum (*A*) producing persistent deformity of the *bulbus duodeni* ("cap"); *B*, normal pyloric canal; *C*, stomach not enlarged. (Original observation by author.)

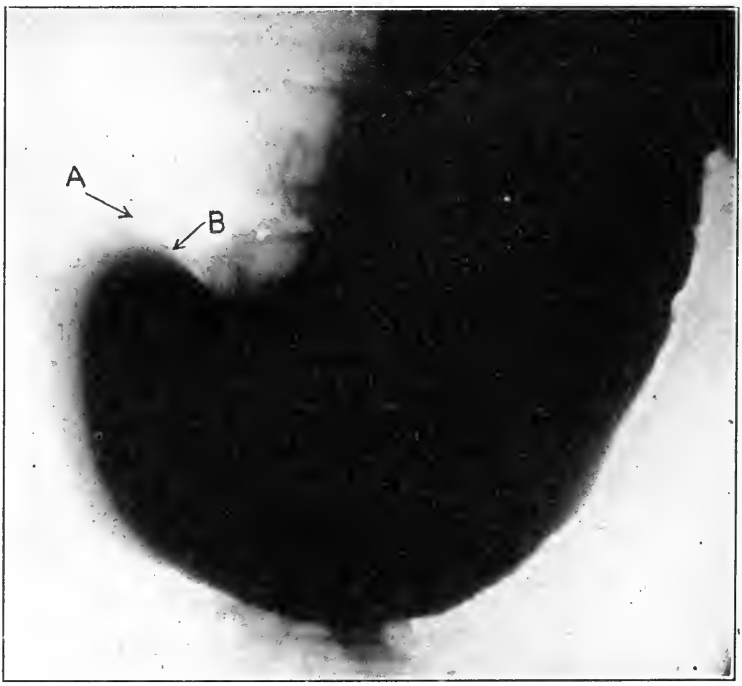


FIG. 268.—Pyloric obstruction with pronounced dilatation of stomach, caused by duodenal ulcer, completely invading *bulbus* duodeni and preventing any visualization of it by barium meal. Ulcer at *A;* pylorus at *B*. (Original observation by author.)

the stomach and duodenum, quite constantly results in proof of food stagnation, but in which mixtures of barium or bismuth pass from the stomach in normal time. The reverse observation may likewise be

made. For this reason, care should be exercised in the interpretation of the functions of the stomach or of the duodenum when the roentgen evidence of six-hour motor meal is present. It should be recalled that the patient's digestive apparatus is not one that is to be called upon to take care of the comparatively small, but relatively very heavy, meal of uniform consistency, temperature and reaction, such as barium or bismuth mixtures, during the course of his life.

Evidence of six-hour motor stagnation should be searched for at several *seances*, and opinion as to the grade of deformity causing the stagnation never should be given unless observations have been made both before and after the administration of atropin or of belladonna to the point of individual tolerance.

Enlargement of the stomach is quite commonly associated with proof of six-hour, opaque-meal stagnation. Such enlargements may be of marked degree in cases where prolonged stenoses have resulted in fatigue of gastric musculature with consequent dilatation of the stomach. In stomachs of this type, the stenosis is not uncommonly found to be far from complete, but the duodenal lesion may be so located as to have caused a high degree of pyloric or of duodenal spasm. In such event, a slightly stenotic lesion, when complicated by spasm, may bring about long periods of increased gastric peristalsis, edema of antral, pyloric or duodenal mucosa, and, functionally, practically complete obstruction to the passage of food from the stomach. If this condition be long maintained, either constantly or at frequent intervals, gastric fatigue and dilatation of the stomach follow.

Retention "flecks" in the duodenum may occur locally, following the administration of a motor opaque meal, with or without six-hour gastric residue. Such usually represent lodgement of the barium or bismuth mixture in the crater of an ulcer, about its ragged edge, or in ampulla-like dilatations near local points of stenosis or puckering. Occasionally, fistulæ between the duodenum and gall-bladder, bowel, pancreas or liver may be represented by such retention "flecks." Care should be exercised lest shadows from foreign bodies, calcified gall-stones, lymph nodes, stones in the right kidney or "flecks" about the ampulla of Vater or in diverticula of the duodenum or jejunum are interpreted as retention "flecks" due to duodenal ulcer.

In complicated duodenal ulcers, the *fluoroscopic observation-meal* quite constantly demonstrates *enlargement or dilatation of the stomach* with or without atony. The stomach may be pulled to the right and partly fixed there, provided chronic, perforative processes in the duodenum have resulted in protective peritonitis. There is frequently *fixation* to the region of the gall-bladder or pancreas in this type of ailment. Displacement of the duodenum or stomach may likewise be manifested where fistulæ have become established. *Gastric hyperperistalsis* is a common observation in recent pyloric or duodenal stenosis. It may be of remarkable vigor. *Reverse peristalsis* is more frequently seen in stenotic lesions than where the pylorus is closed by simple spasm. Vigorous hyperperistalsis may be accompanied by rapid emptying of the "observation" opaque meal provided the stenosis or deformity of the duodenum is not of high degree.

Any extensive lesion in or about the duodenum causes *imperfect visualization of the bulbus duodeni.* Instead of the "chocolate drop" or "liberty cap" -like duodenal bulb, there may be little or no gut visualized. Such occurs in cases of pronounced stenosis. In instances where stenosis is not marked, *deformity* of the *bulbus duodeni* may usually be seen if carefully searched for. This deformity may be missed if only an anterior-posterior view be taken but may be readily proved if the duodenum be fluoroscoped diagonally, laterally or with the subject in different positions. Not rarely, the apparent deformity is better brought out by palpatory massage of the duodenal and pyloric regions. Its extent, with respect to the cause, can be only correctly determined upon examination after the administration of antispasmodic drugs. *Delayed emptying of the duodenum* may be observed in cases where the ulcer is situated rather distantly from the pylorus or where the ulcer is accompanied by marked duodenal spasm.

Palpatory massage of the duodenum not rarely proves definite *fixation of the gut* to the peritoneum, omentum, gall-bladder, liver, bowel or pancreas. It also aids in more clearly proving deformity by filling out ulcer-craters, ampullæ-like dilatations or fistulæ. It may establish the fact that deformity of the duodenum is only apparent, such being actually due to spasms or to inflammation or tumors, stones or cysts in adjacent viscera (gall-bladder, liver, right kidney, pancreas).

Local areas of duodenal tenderness commonly accompany chronic ulceration. These areas may in no way correspond to such areas as have been outlined upon palpation of the abdomen without the aid of the fluoroscope; in fact, the duodenum may actually lie far removed from those zones. Definite areas of tenderness are most readily found in association with anterior wall ulcers or ulcers that have involved the peritoneum. Not rarely, the duodenum is not tender to palpation, but at the fluoroscopic examination a tender area supposed to have been connected with duodenal disease may be shown to occur from a distended gall-bladder, an inflamed right kidney or a gastric ailment.

Plate or film studies usually confirm the fluoroscopic findings in complicated duodenal ulcer. The information from them is rarely of as much value as is the fluoroscopic observation unless the subject happens to be obese, very weak, or unless a series of from 6 to 24 plates or films are made either in a short time or over an interval of twenty-four hours. To be of definite value, diagnostically, the roentgenograms should be made before and after the administration of antispasmodic drugs and with the patient in various positions.

The roentgenograms may furnish visual evidences of stagnation, malposition, enlargement and peristaltic abnormalities of the stomach. They may demonstrate malformation, fixation, obstruction or fistulæ of the duodenum. In certain instances, even though nothing pathologic may be shown in the duodenum, the roentgenograms reveal abnormalities in neighboring viscera.

SURGICAL TREATMENT OF DISEASES OF THE STOMACH.

By J. M. T. FINNEY, M.D.

In the embryo, the entire stomach is practically vertical: As growth progresses, there is a turn on the axis, and the pyloric end slips toward the right hypochondrium until the pyloric axis is almost at right angles to the cardiac. The empty stomach tends to assume a vertical position. The position of the stomach is also influenced by the pressure of neighboring organs and tumors, and by adhesions. In great dilatations of the stomach, it may occupy practically the entire anterior portion of the abdomen.

Gastroptosis is usually associated with a general splanchnoptosis. The portion of the stomach which sags most is usually the central portion, the cardiac and pyloric orifices being more or less firmly fixed. This prolapse may be due to inherent causes, developmental or otherwise, such as dilatation from overloading the stomach with food; but the common causes are from without, such as the dragging of a dilated colon, the weight of tumors, pressure from above as from tight corsets, enlarged liver, disturbed innervation, profound neurasthenia, etc.

Perhaps more than any other viscus, excepting possibly the colon, the stomach is subject to variations in size. Its normal variation is great, reaching a maximum of perhaps 1500 c.c. In case of either acute or chronic dilatation its capacity may reach as high as three to six liters. The walls are thick or thin, depending upon the chronic or acute character of the trouble.

VARIATIONS.

Contraction.—Contraction is found as a congenital condition or associated with some forms of chronic gastritis, scirrhous carcinoma, syphilis, linitis plastica, etc.

Atrophy.—This is sometimes the result of chronic congestion or of chronic inflammation, but it is more often due to a stenosis of the gastro-intestinal tract above the stomach. This is not a true atrophy but rather a functional inactivity resulting in contraction.

Hypertrophy.—Hypertrophy of the stomach wall is usually due to stenosis of the pylorus. It probably always denotes overwork from this cause, except in case of the congenital form observed at the pylorus in infants. It may be found at times of a pretty marked grade, associated with a chronic appendix or gall-stones, due to a spastic pylorus from reflex nervous irritation.

CONGENITAL ANOMALIES.

These anomalies are of rare occurrence. In acephalous monsters, the stomach may be absent. Again, the stomach may not be fully developed, appearing no larger than the small intestine. There may be a deep constriction near the middle, though true "hour-glass stomach" is usually regarded only as an acquired condition.

The cardiac or the pyloric orifice may be stenosed or entirely closed. The stomach may be found in a hernial protrusion, either through the diaphragm into the thorax or through the abdominal wall.

Diverticula are rare, but have been observed.

Occasionally, congenital displacement occurs, due to lack of development of the diaphragm. This is not a true hernia.

Atresia and stenosis of the duodenum has been reported, but is very rare. It is difficult to decide between inflammatory and developmental causes for this condition.

Diverticula of the duodenum are occasionally found near the outlets of the pancreatic ducts. They are not covered by the muscular coats and have been described as herniæ of the mucous membrane, false diverticula, in contradistinction from the true Meckel's diverticula, the latter being covered by a muscular coat. These diverticula may possibly be due to an obstruction further down. They may be congenital, though no case has been recorded at birth. When recognized, they should be excised when possible, or opened and drained.

Volvulus.—Volvulus of the stomach has been observed although it is an extremely rare affection. It is usually found to be associated with some preceding pathological condition; such as cicatricial contraction following ulcer, an "hour-glass" stomach, for instance, or contraction of the lesser omentum, or a too short or misplaced gastrocolic ligament. Kocher describes two types of volvulus, "mesenterio-axial;" *i. e.*, tension around the vertical axis of the stomach, and "organo-axial," *i. e.*, along the longitudinal axis.

These conditions are difficult to diagnose, due to an indefinite clinical picture and are rarely recognized except at operation. The treatment is directed toward disengaging and replacing the twisted viscus, and operative measures designed to prevent a recurrence of the trouble by removing the cause.

BACTERIOLOGY OF THE STOMACH AND DUODENUM.

Since the excellent work of Cushing and Livingood, it is believed that bacterial life may persist in the stomach and upper portion of the small intestine only under abnormal conditions, that is, where there is an obstruction of the pylorus, new growth or perhaps ulcer.

For this reason, operations on the fasting stomach and upper portion of the small intestine are, from the standpoint of infection, less serious than operations upon the large bowel. A few hours after eating, cultures taken from the normal stomach and intestine are, as a rule,

found to be negative. Repeated observations along this line have been made by the writer during the progress of operations for pyloroplasty, and he has been able to confirm Cushing's results. Cultures were invariably found to be sterile when taken from both duodenum and stomach, after the patient has been given the usual routine preparation of sterile feeding, and mouth washes for forty-eight hours previously.

In cases of advanced carcinoma, however, even after this preliminary preparation, streptococci have been found present on several occasions. One case of gastro-enterostomy in which the chains of cocci were found present in cultures taken from the stomach at operation, died on the third day of acute Streptococcus peritonitis.

INJURIES OF THE STOMACH.

The stomach and duodenum, from their more or less exposed position in the abdomen, are liable to various forms of injury. Especially is this true of the stomach when full of food. In case of doubt as to the nature and extent of any severe injury to the stomach or duodenal wall, it is always safer to make an exploratory incision. Where injury is found that endangers the nutrition of a portion of the wall that part had better be resected or drained. After resection or closure of wounds or perforations, particularly if the lumen of the pylorus is in any way encroached upon, it is always safer to perform a gastro-enterostomy before closure of the abdomen. It should not be forgotten that drainage directly to a line of suture in stomach or intestine is almost invariably followed by the development of a fecal fistula upon the withdrawal of the drain. Where possible, a bit of omentum should be interposed between the line of suture and the drain, or used to reinforce the line of suture itself. Care should be taken to remove all particles of food from the peritoneal cavity when cleansing it. Hemostasis should also be rigidly enforced. Ligature of individual vessels is surer than reliance upon a continuous catgut suture.

Rupture.—Rupture of the stomach is invariably the result of severe trauma, such as blows upon the abdomen, or falls. The stomach is usually distended at the time. McClure reports an interesting case that happened recently. During an intratracheal anesthesia, the tube slipped unnoticed from the trachea into the esophagus of the patient. The stomach became distended with ether vapor. It was then observed that the abdomen had become ballooned up, the percussion note everywhere tympanitic, and the liver dulness obliterated. The cranial operation for which the patient had been anesthetized was postponed and the patient was observed for an hour and a half. In this time, however, the leukocytes had begun to rise and an exploratory operation was performed. The abdomen was found to be filled with gas, very little fluid being present. A rupture 4 cm. in length was found in the lesser curvature of the stomach, between the layers of the mesentery and close to the esophageal opening. This was sutured and the patient made an uneventful recovery.

Wounds.—Gunshot and other perforating wounds are usually followed by fatal peritonitis unless operation is performed early. Experiences in the European war seem further to confirm this position.

Prognosis.—The prognosis depends somewhat upon the contents of the stomach, being less serious if the stomach is empty at the time of injury.

Treatment.—As a rule the abdominal cavity need not be drained after an early operation, with slight extravasation of stomach contents. If there is but a small perforation, adhesions may close it and it may heal without further trouble, or a localized abscess may result, and possibly later a gastric fistula. This, however, is rare.

Whenever there is good reason to suspect impending or existing perforation, whether traumatic or pathological, exploratory operation should be performed and the edges of the perforation, if present, should be inverted whenever possible, by a purse-string or mattress suture, with as little tension as possible, and the suture line reinforced with an omental graft stitched over it or wrapped loosely about it. In case of impending perforation, as shown by weakened or thinned intestinal walls, the same procedure should be carried out.

FOREIGN BODIES IN THE STOMACH.

Most commonly, these bodies are swallowed accidentally, or by the insane or mentally deficient, sometimes by professional "sword swallowers," so-called "human ostriches" and the like. Many remarkable cases have been reported from time to time where the stomach has been found to contain junk of all kinds. Hair balls are occasionally observed, particularly in women, due to the habitual swallowing of hair. Many remarkable cases of this condition are reported in the literature.

Treatment.—Foreign bodies in the stomach may have to be removed surgically through a gastrotomy opening, though remarkably large solid objects even of jagged outline have been observed to pass through the entire gastro-intestinal tract, without injury. The writer has on several occasions observed open safety-pins swallowed by children passed without difficulty.

DISEASES OF THE STOMACH.

Syphilis of the Stomach.—This has, until recently, been rarely recognized either before or at the operation. The most characteristic manifestations have been gumma and cicatricial contractions.

Recent observations show that this condition may be diagnosed earlier than is generally supposed and that it is also more common.

Treatment.—The treatment is that usually employed for syphilis elsewhere, except in those rare cases of cicatricial contraction where a gastro-enterostomy or partial gastrectomy may be indicated. It is not always easy to differentiate a gummatous tumor of the stomach from carcinoma, either clinically or at the operation, as the symptoms and

general appearance of the one may very closely resemble the other. Indeed, cases have been reported where the two conditions were found to be co-existent.

Tuberculosis of the Stomach.—Tuberculosis of the stomach is a rare condition and in the vast majority of cases is secondary to and complicated by a preëxisting pulmonary infection. Not infrequently, too, it is associated with intestinal tuberculosis, more or less extensive. These facts very materially influence the surgical treatment. Cases have been reported, however, where the tuberculous lesion seems to have been confined entirely to the stomach. The various avenues of infection are through the swallowing of the tubercle bacilli with the food, through the blood stream or through direct extension from some neighboring organ. The normal gastric juice together with the secretions from the mucosa furnish a certain amount of protection to it, hence the comparative rarity of the affection. Tuberculous ulcerations of the stomach are subject to the same complications and sequelæ as the ordinary so-called peptic variety. The same operative treatment is indicated as in the latter case and the same general rules apply. It should be borne in mind in planning the operative procedure, however, that owing to the nature of the infection and the probable involvement of other organs, these patients do not stand operation well. Preference, therefore, should be given to the simpler procedures where possible.

Linitis Plastica (*Cirrhosis of the Stomach*).—This term was originally suggested by Brinton to designate a particular disease of the stomach, benign in nature, and characterized pathologically by a diffuse or circumscribed increase in the connective tissue, especially the submucous layer. This gives rise to a marked thickening of the stomach walls, resulting in a narrowing of its lumen, a lessening of its capacity and a disturbance of its function. The exact nature of the process is not as yet agreed upon by pathologists. Probably several different pathological processes have been from time to time included under this one heading. Whatever pathologically it may prove to be to start with, certain it is that the vast majority of these cases terminate as carcinoma. It would be well then at the outset to treat all these cases as if they were carcinoma or the precancerous stage of a definite condition. Syphilis has been found to be a factor in at least one case observed by the writer. The disease is fairly common, although the diagnosis is rarely definitely made except at the operation or autopsy. The *x*-ray is valuable as an aid to diagnosis. Gastrectomy, more or less complete, is indicated in cases where the conditions are found to be sufficiently favorable. Where the process is limited to the pyloric portion, gastroenterostomy is the operation of choice. If this is impracticable, jejunostomy may be considered.

TUMORS OF THE STOMACH.

Myomata, Papillomata.—Myomata, papillomata, etc., are reported in the literature with relative frequency. Their presence gives rise to

few symptoms, unless from their size or position they may produce obstruction to the passage of the food. When the tumor is pedunculated and situated just in front of the pylorus, it may give rise to attacks of intermittent obstruction, more or less complete, as in a very interesting case recently observed by the writer. The constant appearance of blood in the stools, not otherwise accounted for, is most suggestive. The chief significance of these tumors is their proneness to degenerate into malignant disease, the myomata into sarcomata, and the papillomata into carcinomata. Hence, where they are recognized, they should be promptly and completely excised. This is especially true of the bases of the tumors, as it is here that the malignant process has its origin. Excision of the entire thickness of the gastric wall should always be done with a wide margin of normal tissue when local measures are deemed sufficient. Otherwise, the usual partial or more or less complete gastrectomy should be performed, as for carcinoma.

Sarcoma of the Stomach.—This is a rare affection although the literature of the subject contains reports of an ever-increasing number of cases, suggesting the possibility that the condition may have been overlooked in the past. It is rarely recognized before operation, usually not until after histological examination. There is no marked difference generally noted in the clinical course from that of carcinoma, unless it may be that the loss of weight, general debility and cachexia are not so pronounced as is usually observed in a case of gastric carcinoma equally advanced. The operative indications are the same as those for carcinoma. Resection of the tumor mass is to be carried out where possible. Metastasis takes place relatively late as compared with carcinoma, making the prognosis, on the whole, rather better.

Cancer of the Stomach.—Medical Treatment.—Medical treatment offers absolutely nothing so far as a cure is concerned and can have no place in this disease except as a means of alleviating the discomfort of the inoperable cases.

Surgical Treatment.—At the present time surgery offers the only possibility of a cure and for the patients upon whom radical operation cannot be performed it may be a means of prolonging life and relieving suffering, due chiefly in these cases to pyloric obstruction. From the standpoint of treatment cases of carcinoma of the stomach fall into two groups: (1) Those cases in which there is evidence of metastasis, *i. e.*, supraclavicular glands, nodular liver, marked cachexia, etc., and when there is no obstruction at the cardia or pylorus. (2) All other cases in which a diagnosis of carcinoma of the stomach has been made or where it is suspected.

Nothing is to be gained by operation in the first group and such cases should be treated symptomatically along medical lines. In this connection, Woolsey has well said: "Indiscriminate exploration in advanced cases is to be condemned, especially if no obstruction of the pylorus is present that may be relieved by a palliative operation. These explorations give a considerable mortality, do no good, and discredit gastric operations in general." At the same time, the patient has

little to lose and everything to gain and should be given the benefit of any reasonable doubt.

The second group should be treated surgically by one or more of the following methods:

1. Exploratory incision.
2. Gastro-enterostomy.
3. Two-stage operation, *i. e.*, gastro-enterostomy, followed later by partial gastrectomy.
4. Gastrectomy: (*a*) Partial:
   Pylorectomy.
   (*b*) Complete or subtotal.
5. Gastro-esophagostomy.
6. Gastrostomy.
7. Jejunostomy.

The types of operation selected for any given case will depend on the conditions found at operation, the general physical condition of the patient and the probable benefit to be derived.

Indications and Contra-indications for Operation.—*Exploratory Incision.*—(*a*) Exploratory laparotomy should be performed in every case in which there is any possibility of the presence of carcinoma if the patient is seen by the surgeon early enough in the course of the disease to offer any hope of cure or adequate relief. Especially is this true in cases that give a long history of gastric disturbance, in which there has recently been some change in symptoms which would lead one to suspect that an existing ulcer had undergone some malignant change.

(*b*) The existence of a palpable or large tumor does not necessarily mean that the tumor is inoperable, as was formerly supposed. If a tumor is palpable, it oftentimes is an indication that it has a certain amount of mobility while, on the other hand, tumors which are fixed or involve the lesser curvature are often so highly placed as to be out of reach of the palpating fingers. It has also quite frequently been observed that large, slowly growing tumors do not metastasize or become adherent to neighboring organs as early as the smaller and more malignant growths. An exploratory incision, therefore, should unhesitatingly be performed in these cases when possibly a few years ago it would not have been advised.

Gastro-enterostomy.—(*a*) Undoubtedly it is the operation of choice where there is a tumor at the pylorus which is causing obstruction and which, owing to extensive invasion of surrounding structures, cannot safely be excised. (*b*) In cases in which the tumor seems inoperable but in which the patient has been much debilitated as a result of starvation from pyloric obstruction, it may, by the relief of such obstruction, so improve the patient's general condition that a partial gastrectomy can later be performed with much greater safety. It has occasionally been observed that a tumor which was fixed and seemed inoperable at the time the gastro-enterostomy was performed has, following such an operation, become movable and possibly operable.

(*c*) The benefit to be derived from gastro-enterostomy in cases without obstruction is doubtful, as there seems to be a considerable mortality in these advanced cases. Operative statistics show conclusively that if the growth is confined to one or other of the curvatures, and if neither stenosis nor stasis is present, gastro-enterostomy offers little. It will not prolong life nor will it give a greater degree of comfort and, therefore, should not be performed under these circumstances.

Gastrectomy.—(*a*) Gastrectomy, partial, subtotal or complete, should be performed in every case of carcinoma of the stomach in which there is any reasonable possibility of securing a radical cure, provided always that the patient's general condition is such as to warrant it. (*b*) There are many surgeons who believe that partial gastrectomy is the operation of choice even where it is impossible to remove all of the metastatic glands, especially when there is a large sloughing growth which is causing obstruction, the argument being that the removal of the growth and the obstruction at one and the same time relieves the patient to a great extent of the toxic symptoms, and that the recurrence of the growth does not usually take place in the stomach and consequently the existence of the patient is made much more comfortable. Those who favor this procedure in such cases, state that the mortality from such operations in competent hands is not any greater than that following simple gastro-enterostomy. W. J. Mayo makes the statement that the radical operation is justified in these cases, as some of them have lived beyond the five-year limit. It should also be borne in mind that in some cases the glandular hyperplasia is the result of the infection rather than metastasis.

The contra-indications to the performance of partial gastrectomy as a radical cure for cancer of the stomach may be given as follows: When the growth is firmly fixed to neighboring organs and has directly invaded them; when it is evident that it would be impossible to remove all of the involved lymphatic structures and when there are metastases in the liver. Fixation of the growth to the anterior surface of the pancreas which von Mikulicz thought increased the mortality almost to the point of prohibition has since been proved not to be strictly true, and experience has shown that a superficial portion of the pancreas may be removed with the growth without greatly increasing the mortality. Direct involvement of the transverse colon, also, is not to be considered an absolute contra-indication, as a number of cases are now on record in which a portion of the transverse colon has been resected, together with the tumor in the stomach with subsequent recovery.

Gastro-esophagostomy.—This operation for the radical cure of carcinoma of the cardia which has been successfully performed in a few instances has recently been more closely brought to the attention of American surgeons by Willy Meyer. In view of the high mortality, the technical difficulties of the operation and the almost inevitable certainty of recurrence it would appear that gastrostomy offers more to the patient at the present time than this very extensive operation.

Gastrostomy.—Gastrostomy by any of the well-known methods should be performed in cancer of the cardia when the obstruction has reached a point where liquids cannot be swallowed. By means of it thirst is to a very great extent relieved and sufficient nourishment may be given to prevent death from starvation.

Jejunostomy.—Jejunostomy is indicated when there is such an extensive involvement of the stomach that gastrostomy or gastro-enterostomy cannot be performed. The most evident need of it perhaps is seen in advanced cases of linitis plastica.

The Relationship between the Lymphatics of the Stomach and Gastrectomy.—The course of the lymphatics which originate in the pyloric region and the situation of the lymphatic glands has determined the lines of section of the stomach and duodenum in the radical cure of cancer in that region. The greater number of the lymphatics from the pyloric area have an oblique course toward the cardia and empty into the coronary group of glands lying in the gastrohepatic omentum and along the lesser curvature. These glands, in turn, relay to the upper coronary gland in the falx coronaria. The smaller number of lymphatics draining the pyloric region take two courses, one set drains to the glands in the gastrocolic omentum (the gastro-epiploic glands) and from these glands the drainage is into the subpyloric glands or those situated along the upper border of the pancreas. A few lymphatics follow the course of the pyloric artery and enter one or two glands along its course, these, in turn, draining into a set of glands along the stem of the hepatic artery. It can therefore be stated in general terms that the lymphatic glands with which we are concerned in the radical operation for cancer of the pylorus are found along the course of the main vessels and quite closely associated with them. As the coronary glands are chiefly involved, and as they extend along the whole of the lesser curvature, it is essential that the whole of the lesser curvature be removed. The gastro-epiploic glands do not reach beyond the middle of the greater curvature of the stomach, so that it is only necessary to carry the line of section to this point or slightly beyond it. The subpyloric glands are removed by carrying the dissection on the duodenum for from one to two inches beyond the pylorus to the superior border of the pancreas. The glands along the course of the pyloric artery, if present, will probably be near the stomach and removed with it. To undertake the dissection and removal of the secondary groups of glands, such as those around the cardiac orifice and along the course of the hepatic vessels, is not feasible.

Partial Gastrectomy or Pylorectomy.—This operation may conveniently be divided into two steps: (1) the removal of the affected portion of the stomach and (2) the method of union between the stomach and the duodenum. The abdominal cavity having been opened through a right rectus incision and palpation and examination of the growth, lymphatic glands, and surrounding organs having shown that it is operable, the first step of the operation is carried out as follows: The coronary vessels are doubly ligated and divided just at

the point where they enter the stomach to the right of the cardia. The gastrohepatic omentum is ligated and divided. About the middle of the greater curvature, or further to the left if necessary to avoid the growth, the gastro-epiploica sinistra vessels are doubly ligated and divided. The gastrocolic omentum is ligated and divided at as great a distance as possible from the stomach wall in order to include the lymphatic glands lying in it. Next a rubber-covered clamp is placed across the body of the stomach from the point of ligation of the gastro-

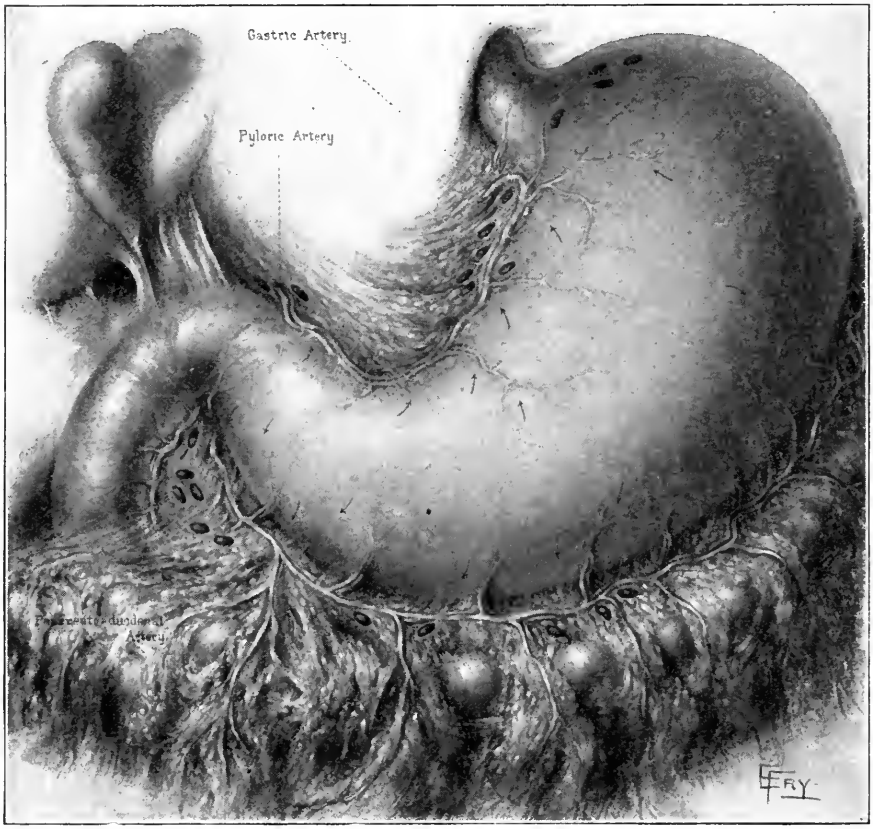


FIG. 269.—Distribution of the lymph vessels of the stomach. (William J. Mayo.)

epiploica sinistra to the point of ligation of the coronary vessels. Another clamp is placed about one inch to the tumor side of the first clamp and the stomach divided with a cautery between them. The stomach is then reflected toward the right and the pyloric vessel exposed and tied as the other vessels have been. By proceeding with the dissection in this manner, the middle colic vessels will be seen lying almost directly behind the pylorus and can thus be more readily avoided than by carrying the dissection from the pylorus toward the left. Injury to the middle colic vessels may result in gangrene of a

portion of the transverse colon and will necessitate its immediate resection and hence is a serious complication. If the growth is adherent to the anterior surface of the pancreas, it may be necessary to remove a portion of the pancreas with it The dissection of the duodenal wall should be carried well beyond the pylorus, possibly as much as two inches. The duodenum is crushed, a clamp is placed on the stomach side and a catgut ligature placed about the crushed portion of the duodenum and division of the duodenum made, between the ligature and the clamp,

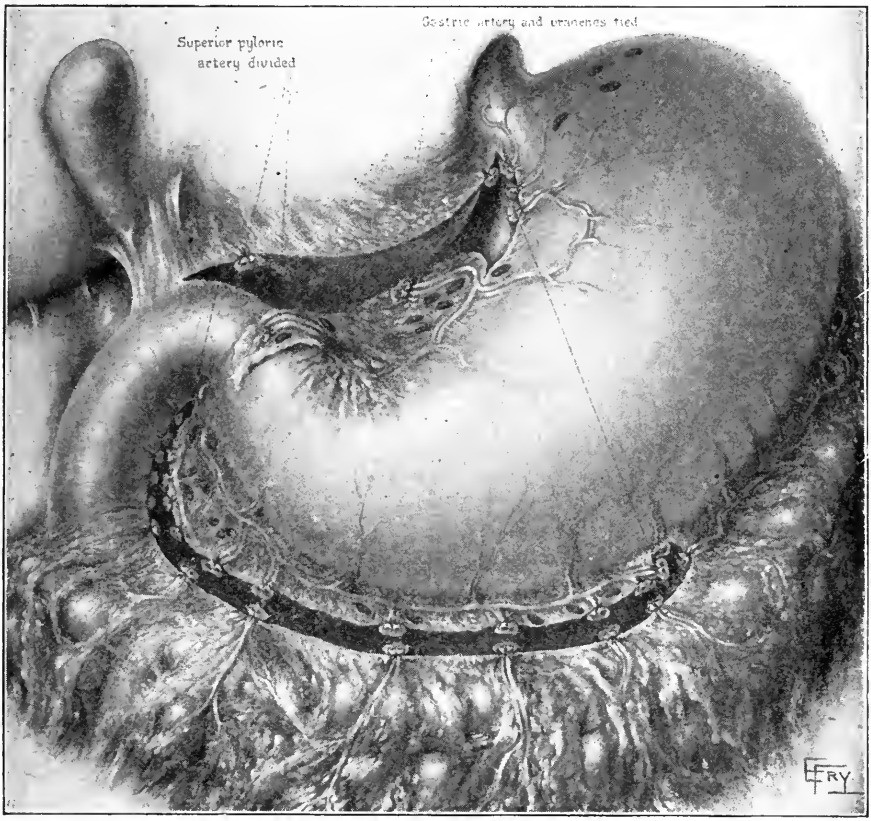


FIG. 270.—Cancer of the lesser curvature of the pyloric end of the stomach, with separation of the lymphatic groups. Dotted lines show proposed resection. (William J. Mayo.)

with the actual cautery. The stump of the duodenum is then inverted by means of a purse-string suture previously placed. Indeed, the technic for the duodenal stump is the same as that for the appendix. In cases in which the pancreas has been injured or partially resected the free end of the duodenum should be utilized to cover the injury by suturing it over the raw surface of the pancreas. This completes the dissection and allows complete removal of the involved portion of the stomach, together with its lymphatic glands. Some surgeons prefer to divide

the duodenum first and then reflect back the stomach and dividing it between two clamps after tying off the blood supply. (2) The technic to be followed from this point on varies with the method of anastomosis selected. The two methods known as "Billroth No. 1" and "Kocher's method" are not much in vogue in this country and will not be discussed in detail.

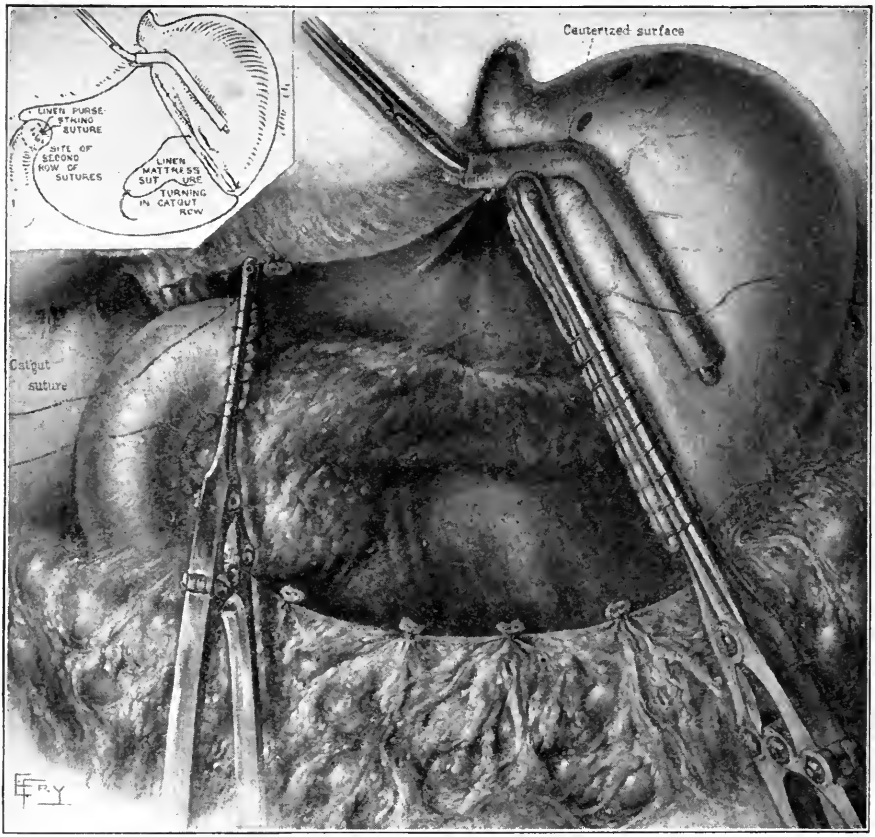


FIG. 271.—Method of closure of the ends of stomach and duodenum by continuous chromic catgut suture, to be followed by musculoperitoneal suture of linen (see small diagram. (William J. Mayo.)

In using these two methods the duodenum should not be crushed and ligated, as it is used for a direct anastomosis with the stomach. In the "Billroth method No. 1," the open end of the stomach, beginning at the lesser curvature, is closed down to a point, the distance of which from the greater curvature corresponds to the transverse diameter of the duodenum and then the open end of the duodenum is anastomosed to the stomach at this point. The objection to this operation is the danger of leakage at the angle where the three suture lines meet. In "Kocher's method" the open end of the stomach is completely closed by

sutures and the anastomosis is made by implanting the open end of the duodenum into the posterior wall of the stomach. The objection to this method is that if enough stomach has been removed, the gap to be bridged is wide and there will be tension and consequent danger of leakage. The method most commonly used is the "Billroth No. 2," which consists in complete closure of the open end of the stomach and the performance of a no-loop posterior gastrojejunostomy. The

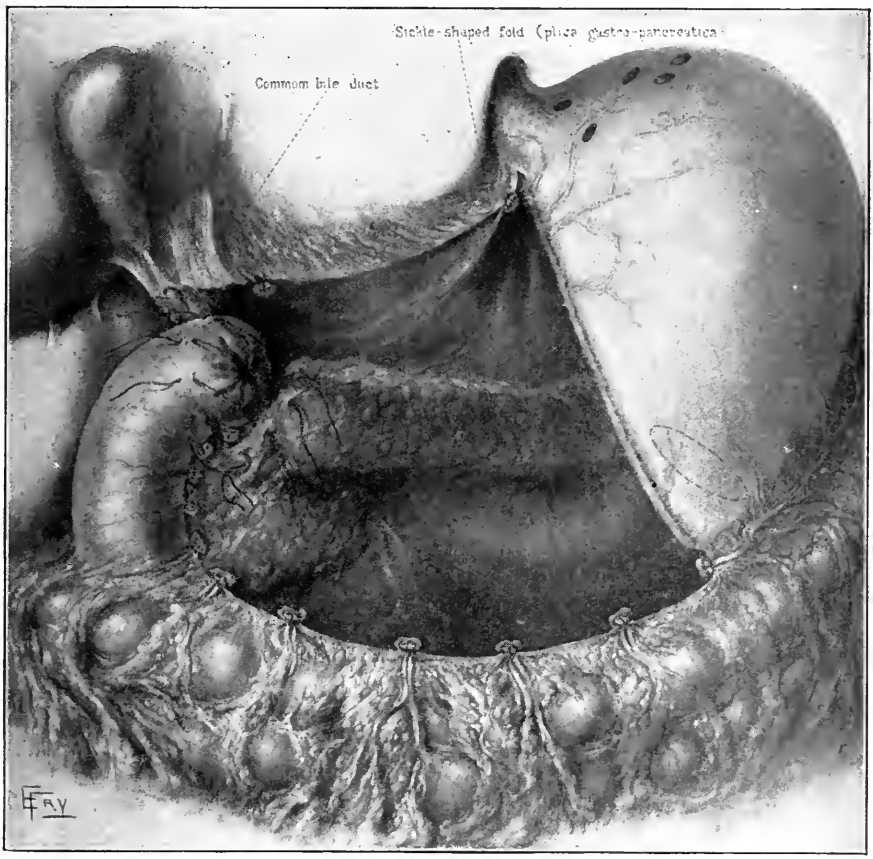


FIG. 272.—Interrupted sutures tying stump of duodenum to pancreas. Dotted lines show posterior gastro-enterostomy. (William J. Mayo.)

closure of the open end of the stomach is made by inserting a continuous interlocking suture of catgut, taking in all the coats of the stomach, the clamp is then removed and the first suture line turned in by a continuous Lembert or Cushing suture of silk. If there is much tension this should be reinforced by a few interrupted sutures. A posterior no-loop gastro-enterostomy is performed in exactly the same manner as for other lesions of the stomach.

Another method of making the anastomosis between the stomach and

intestine has recently come into use which is known as the Polya-Reichel method. It is carried out as follows:

The duodenum is tied off and inverted as in the previous method, but the open end of the stomach is not closed. An opening is made in the transverse mesocolon, and the upper part of the jejunum pulled through until it can be easily brought into contact with the stomach. The open end of the stomach, with the clamp still in place, is united to the

FIG. 273.—Showing excavation in pancreas following resection of pyloric end of the stomach with pancreatic involvement. The end of stomach and end of duodenum both closed. (William J. Mayo.)

side of the jejunum by a continuous posterior suture of silk or catgut. A rubber-covered clamp is next placed on the jejunum and another similar clamp placed across the stomach beyond the crushing clamp which is then removed. An opening is made in the jejunum of a length corresponding to the open end of the stomach. The mucous membranes of the posterior walls of the stomach and jejunum are next approximated by a through-and-through continuous interlocking catgut suture. Should the length of the stomach opening be greater than one desires

to open into the jejunum, then the sewing together of the end of the divided stomach and the opening of the jejunum may be accomplished by shirring the edge of the stomach, *i. e.*, so placing the sutures as to take more of the stomach wall in each suture bite than is taken in the walls of the jejunum. The clamps are then loosened and any bleeding-points ligated. The anastomosis is completed either by an anterior row of mattress sutures of silk with intermediate Lembert sutures or by a continuous silk suture. The anastomosed end of the stomach

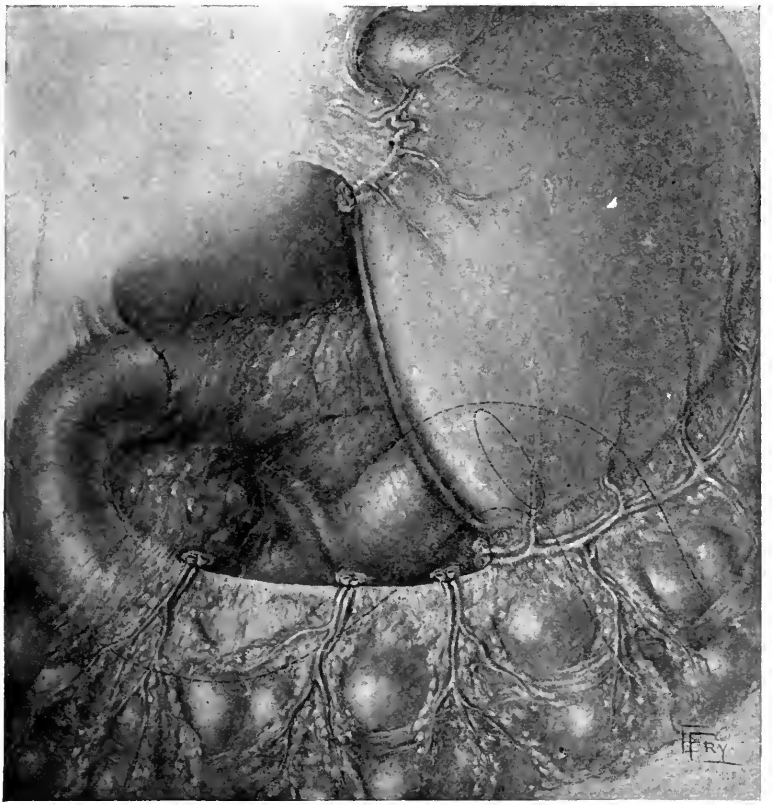


FIG. 274.—Showing operation completed. Closed end of duodenum buried in excavation in pancreas. (William J. Mayo.)

is then drawn through the opening in the transverse mesocolon and the margin of the opening sutured to the wall of the stomach as in gastro-enterostomy. Mayo, in calling attention to this operation, brings forward the following advantages: It saves the time consumed in closing the end of the stomach, and in cases in which only a small pouch of the stomach is left it is very much easier than an independent gastro-enterostomy. Instead of shirring the stomach walls in making the anastomosis, the opening in the stomach may be partly closed, preferably from the lesser curvature, and the opening thus made of

any desired size. Catgut may also be used throughout as is done in the Mayo clinic. The anastomosis may also be made in front of the transverse colon instead of through the mesocolon. Some surgeons prefer this position as less liable to subsequent obstruction.

Two-stage Operation.—In the two-stage operation a posterior no-loop gastro-enterostomy is done at the first sitting, care being taken to place the anastomosis in such a position that it will not interfere with the subsequent operation. At the second sitting a pylorectomy is performed in exactly the same manner as if no previous operation had been done, the duodenum and open end of the stomach being closed as in the "Billroth method No. 2."

FIG. 275.—Bloodvessels tied, glands separated, crushing clamps in place, and also clamps to prevent leakage from part to be removed. Upper left drawing shows stump of duodenum in crushing clamp, with suture placed for closing. (William J. Mayo.)

Complete or Subtotal Gastrectomy.—The incision which gives the best exposure for complete removal of the stomach is that advocated by Marwedel. This incision is about one inch below the left costal margin, extending from the midline to about the tip of the tenth rib. The muscles are divided and the seventh, eighth and ninth costal cartilages incised at their junction with the ribs. In this way it is possible to turn upward a large flap, giving free access to the cardiac end of the stomach.

The total removal of the stomach is performed in almost the same way as a partial resection, the gastrohepatic and gastrocolic omenta being divided as in that operation and the vessels tied in a similar way, except that the gastro-epiploica sinistra is ligated near its origin from the splenic and the gastric ligated at its trunk rather than after it has branched, as in a pylorectomy. The duodenum is crushed and ligated with catgut and inverted with a purse-string suture. The esophagus is pulled down as far as possible and the division made as close to the stomach as is safe in order that one may have the portion of the esophagus

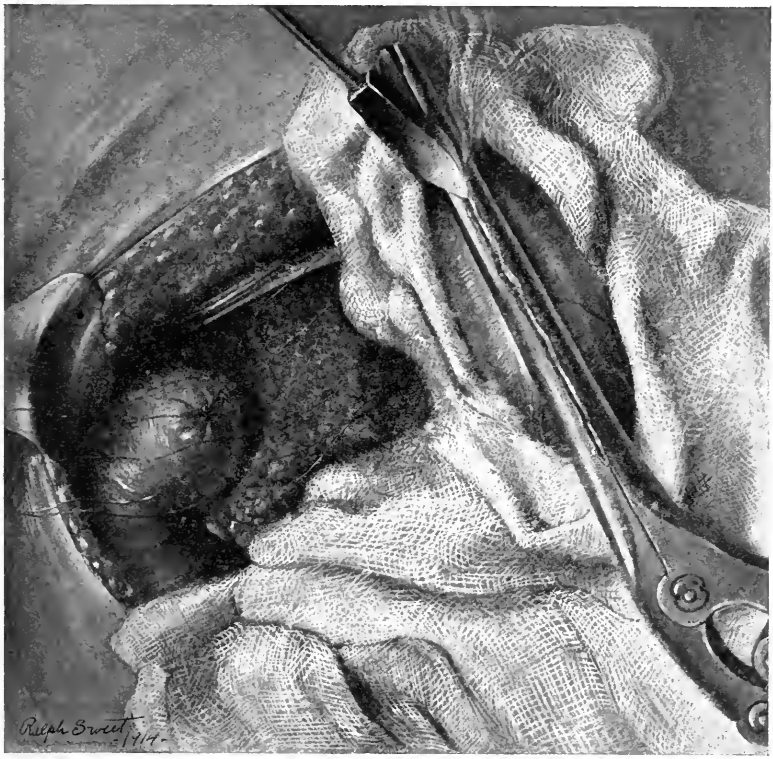


FIG. 276.—Crushing clamp on the stomach. Cautery used to sterilize and prevent carcinomatous implantation. Stump of duodenum closed. Sutures placed to turn the duodenal stump into the denuded head of the pancreas. (William J. Mayo.)

within the abdominal cavity, which is covered with peritoneum for anastomosis. The anastomosis is then made by implanting the end of the esophagus into a loop of jejunum which has been brought up through the transverse mesocolon, a double row of silk sutures being used.

Gastro-esophagostomy.—For full details as to the technic of performing this operation, the reader is referred to the article by Dr. Willy Meyer on "Surgery of the Esophagus," page 17, and to the article by the same author in the *Annals of Surgery*, December, 1915. Briefly it may be described as follows:

An oblique incision is made parallel with the left costal border, running upward into the axillary line and the incision carried through muscles into the peritoneal cavity. A place in the body of the stomach is selected for transverse division and the gastrocolic and gastrohepatic omenta are doubly ligated and divided from this point toward the cardia. Two clamps are then placed across the stomach and the distal end closed by the same method as is used in closing the proximal

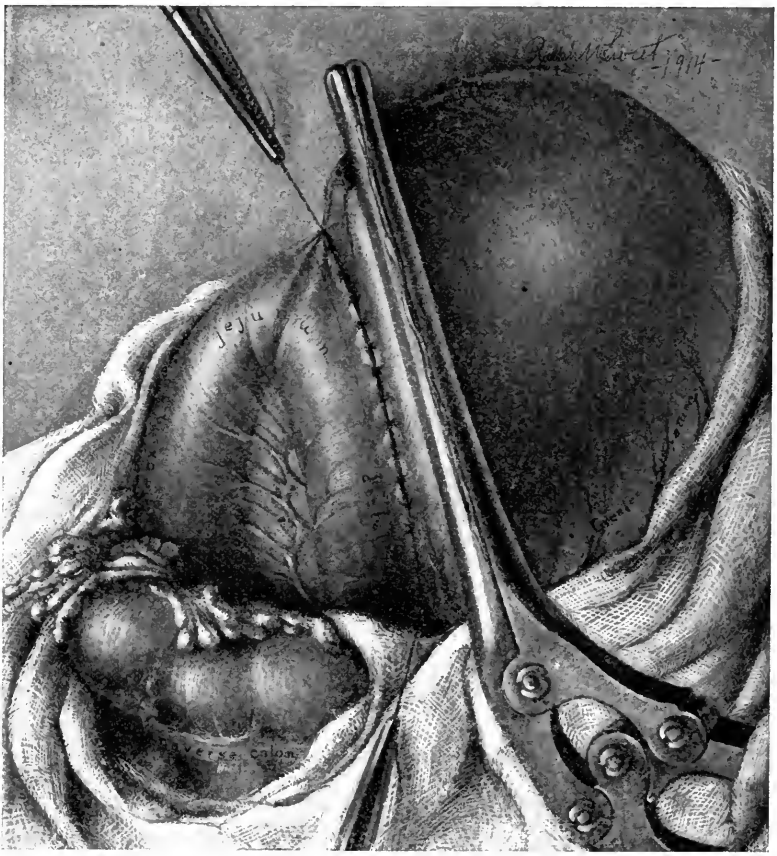


FIG. 277.—Upper jejunum, six to twelve inches from origin, brought through an opening which has been made in the transverse mesocolon and united by outer row of seromuscular silk sutures to the posterior wall of the stomach. (William J. Mayo.)

end in pylorectomy. The esophagus is then pulled down as far as possible, the two vagi divided and a curved clamp placed across it above the limits of the growth. About one inch proximal to this clamp the esophagus is tied with a tape whose ends are left long. The affected portion of the stomach is then free and may be removed. A Witzel gastrostomy is performed and the abdomen closed. A second incision is made in the seventh interspace on the left side, opening the chest and

the ribs spread apart with a rib-spreader. The esophagus is freed from its bed about the arch of the aorta. At this stage of the procedure the anesthetizer places an olive-tipped bougie down the esophagus and a second ligature is placed about it above the olive-tip. An incision is also

FIG. 278.—Crushing clamp removed from the stomach and holding clamps applied to jejunum and stomach to prevent soiling. (William J. Mayo.)

made in the left side of the neck, such as one would use for external esophagostomy. The anesthetizer, by pulling on the bougie, brings the end of the esophagus, with its long tape, up so that it presents in the neck and can then be pulled out of this incision. The chest wound is

then closed, the ligature above the olive-tipped bougie is cut, allowing withdrawal of the bougie. The subcutaneous tissues over the front of

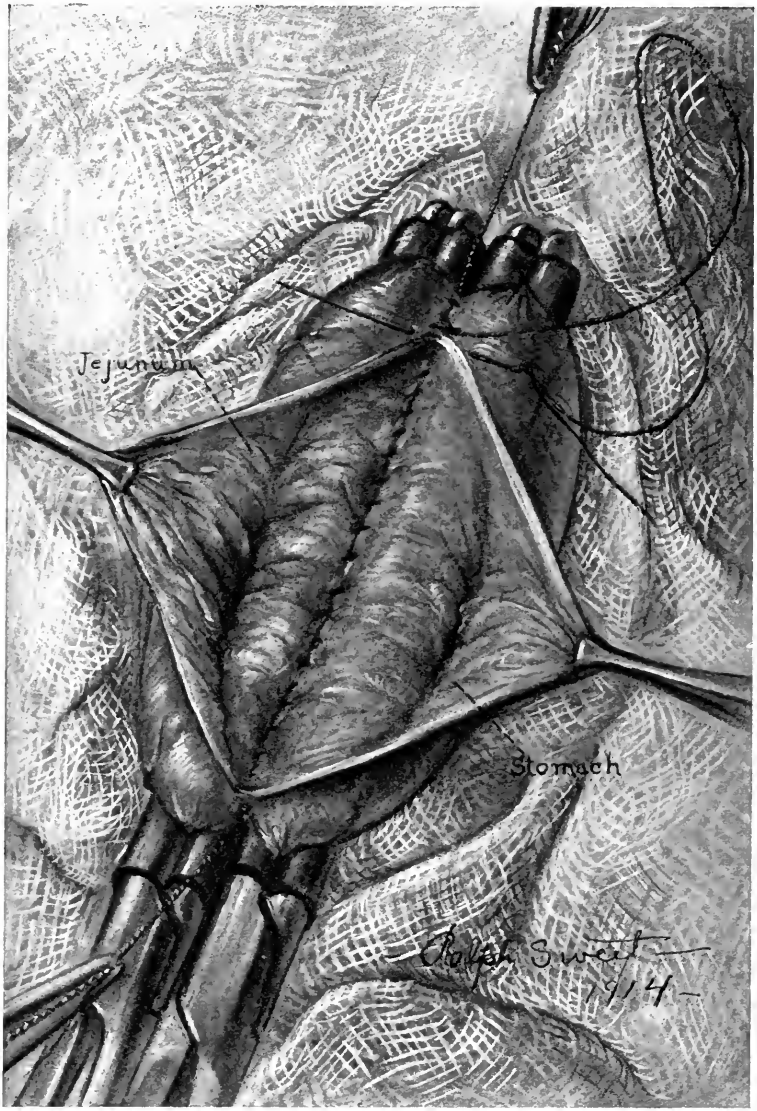


FIG. 279.—Inner row of catgut through-and-through sutures applied to the posterior walls, uniting jejunum to cut end of the stomach and continuing part way down the anterior wall. (William J. Mayo.)

the chest are undermined and the esophagus pulled down under the skin as far as it will reach and there sewed to a small opening in the skin. This can be later connected with the tube used for the gastrostomy.

The after-treatment of cases that have been operated upon for stomach trouble is of prime importance. Not a few of the bad results that have been observed may be traced to errors in diet either as regards the quantity or quality of food taken and the time and method of administration subsequent to the operation. It is a good rule to follow "to err on the safe side," that is, not giving much food for the

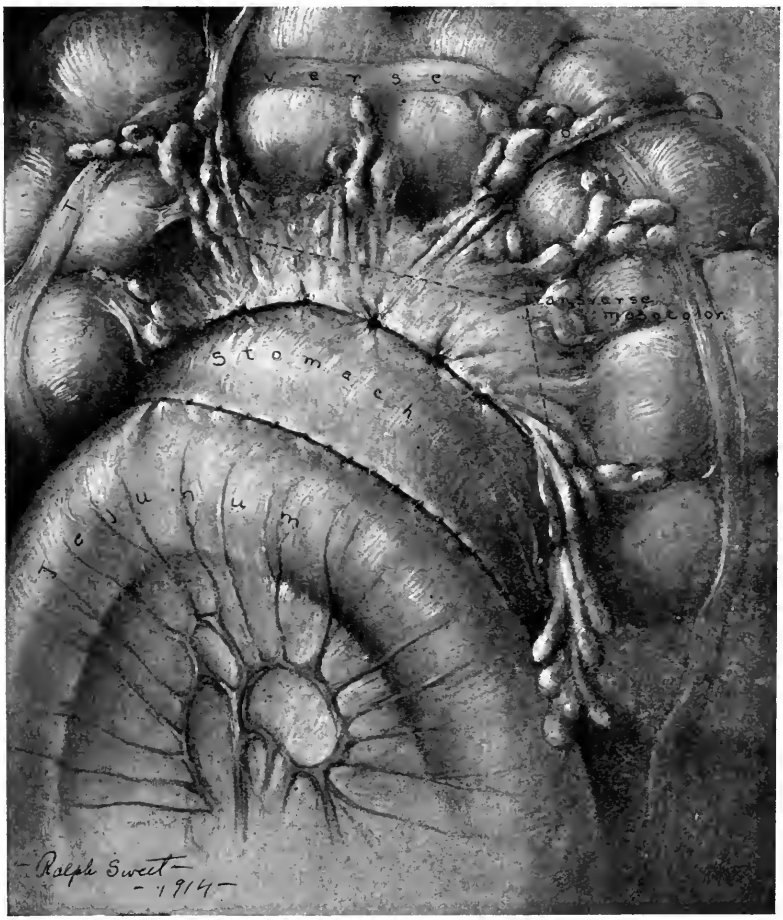


FIG. 280.—Anastomosis completed by an entire row of seromuscular silk sutures. Anastomosed end brought through the opening in the transverse mesocolon and margins of opening sutured to the stomach. (William J. Mayo.)

first few days following operation. Water administered by the Murphy drip method, or, better still, 5 per cent. solution of bicarbonate of soda and lactose, are all that is necessary during this period. Several liters of these solutions may be absorbed in twenty-four hours and relieve thirst and lessen the dangers of acidosis. After twenty-four hours water may be given by mouth in small quantities and a little egg

albumen or broth. Fluids only should be allowed for the first four or five days, then gruels, eggs, fruit juices and other soft articles of diet. After a week, tender meats, purees of vegetables and stewed fruits, etc. The quantity should be carefully regulated as well as the quality for some time. Posture has considerable effect upon these cases. Most stomach cases do better after operation in the sitting posture than prone. This is particularly true of the first few days. By paying careful attention to the diet immediately after the operation one can lessen the amount of gastric distress and the troublesome postoperative diarrheas that have been observed, particularly in that class of cases in which prolonged starvation has been present. If one has been careful and painstaking in placing one's sutures there is no contra-indication to the use of the stomach-tube after operation upon the stomach, and it is often of great service when carefully used. There is no valid objection to the use of sufficient morphin to keep these patients reasonably comfortable for the first few days after operation when they need it.

Cysts.—These are rare and do not usually occur in connection with the stomach and duodenum but are generally ascribed to a detached Meckel's diverticulum, even when found in the mesentery. These cysts occasionally reach a very large size, and their walls include all the walls of the intestine. The epithelium is sometimes smooth and ciliated, but it may exhibit more or less perfect glands and villi. The treatment is complete excision where possible. If this cannot be done, then evacuation of the contents of the cyst, cauterization of its walls and packing of the cavity with gauze in order to stimulate the growth of granulation tissue and the contraction and obliteration of the cavity, should be employed.

HEMORRHAGE FROM THE STOMACH.

Except in case of trauma, it is rarely necessary to operate for gastric or duodenal hemorrhage. The hemorrhage may be very profuse, even fatal, from a large bloodvessel eroded by an ulcer or by a carcinoma. Deaths are now and then reported from postoperative hemorrhage where a gastric or intestinal resection or suture has been done. Such unfortunate results are usually due to the fact that the cut bloodvessels along the line of suture have not been ligated at all, or insecurely so. Operations upon the stomach, in case of gastric hemorrhage from congestion of the portal circulation from any cause, are not indicated.

Treatment.—Too much care cannot be taken in the absolute control of hemorrhage after incisions into the stomach wall. Too much reliance should not be placed in the continuous suture to accomplish this, as it is uncertain at best. It is safer always before suturing to loosen the clamps and ligate each individual vessel separately. In the majority of cases, this may not be necessary, but it should not be forgotten that it is the hundredth case that may need it, and hence it should not be disregarded. The presence of occult blood in the stools, while not

absolute evidence of the presence of ulceration of the stomach or intestine, is so strongly suggestive of it that when persistent and otherwise unaccounted for, it constitutes sufficient indication upon which to advise exploratory laparotomy and gastrotomy in order to establish a definite diagnosis, or to apply treatment.

OBSTRUCTION.

Obstruction to the entrance of food into the stomach through the cardiac orifice may be due to a muscular spasm or to organic stricture at that point, congenital or acquired. Some years ago the writer was called to see a newborn baby with a history of persistent vomiting of all the food it had taken since birth. The passage of a small catheter into the esophagus showed an impervious stricture just at the cardiac orifice. I therefore operated and found a very small stomach showing a complete stricture at the cardia. A gastrostomy was done. The baby did not survive, dying some days later, although the gastrostomy worked satisfactorily. This condition is rare.

Treatment.—Various methods of treatment have been suggested to relieve muscular spasm. The operation of Mikulicz dilates very thoroughly the cardiac orifice. Through a gastrotomy incision in the anterior wall a pair of dilating forceps are passed up into the cardia and that orifice is thoroughly stretched. Later less radical measures have become popular, such as dilatation by means of a water-bag introduced through the mouth and placed in position in the cardia, which is then subjected to hydrostatic pressure. Plummer has brought this method prominently before the Profession and reports satisfactory results. It should always be tried before resorting to more radical measures.

PYLORIC STENOSIS.

Except for those cases of spastic contraction of the pylorus due to reflex irritation from a chronic appendix, or gall-bladder disease, pyloric stenosis in the adult is, in general, due to the cicatrization of gastric ulcers in the process of healing. Obstruction may also be caused by carcinoma or inflammations, as with acute ulcer in this region. Pedunculated papillomatous growths arising from the gastric mucosa near the pylorus may occasionally produce intermittent obstruction by becoming engaged in it.

Congenital pyloric stenosis may persist until adult life. Recently an undoubted case of this condition was seen and treated at the Johns Hopkins Hospital in a girl, aged seventeen years. The patient for years had been bothered by vomiting. The stomach held about two quarts, and always had a large retention. The pylorus was found to be much thickened and hypertrophied, with no sign of ulcer. A Finney pyloroplasty was done, with complete cure of the condition.

HOUR-GLASS STOMACH.

This condition as met with by the surgeon is probably always secondary to some preëxisting ulcerative or cicatricial process. As the

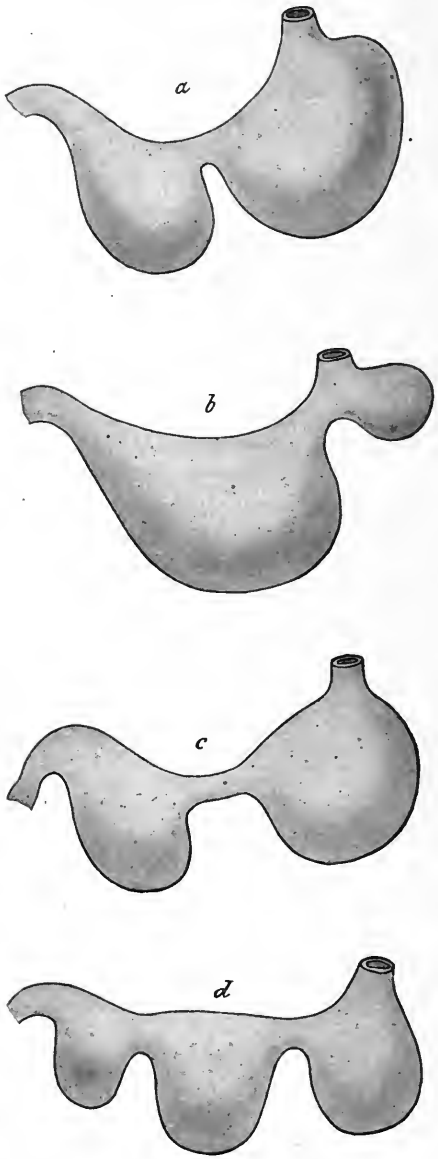


FIG. 281.—Varieties of hour-glass stomach. *a*, ordinary form of hour-glass stomach in later stage, the pyloric pouch being also dilated; *b*, author's case, in which a small pouch of the dome was separated from the remainder of the stomach by a constriction; *c*, author's case, in which the stricture formed a narrow tube connecting the two cavities; *d*, author's case; in which there were three cavities. (Keen's Surgery.)

name implies, the stomach is divided into two more or less well-defined pouches of varying sizes, with a band of cicatricial tissue between, sufficiently contracted and inelastic to produce appreciable obstruction to the passage of the food. The surgical problem involved is to enlarge the opening present sufficiently to allow the free passage of the food or to make a new one. Occasionally, pyloric stenosis is observed in connection with the hour-glass contraction. The writer has recently observed such a combination. This materially complicates the situation and involves the necessity of performing in addition a pyloroplasty or a gastro-enterostomy. The two gastric pouches are united, preferably by a pyloroplasty (Fig. 281), as the simplest and usually the most satisfactory procedure, or the cicatricial bridge may be excised and the two segments of stomach united, or a gastrogastrostomy or a simple gastrostomy may be done.

ACUTE DILATATION OF THE STOMACH.

Following abdominal operations, acute dilatation of the stomach is a complication the possibility of which should ever be kept in mind, for unless prompt and vigorous treatment is instituted a fatal issue may result. This affection is fortunately not of frequent occurrence but always serious. It has been observed where there has been no antecedent surgical operation. Frequently, at autopsies, the stomach is found to be markedly dilated, but the prevailing opinion is that this is due to postmortem conditions.

Acute dilatation of the stomach is accompanied by and possibly due to filling up with gas and great overdistention with fluid.

The dilatation may be of reflex nervous origin, with simple loss of tone of the gastric walls. In perhaps one-half of the recorded cases a more or less definite mechanical obstruction has been made out. Sometimes it has been found at the pylorus, but usually in the last portion of the duodenum where it is constricted between the taut mesenteric vessels and the vertebral column, the so-called gastromesenteric ileus. Kinks, contractions and adhesions and pressure of misplaced organs may all tend to bring this about.

Acute dilatation, as a rule, comes on shortly after operation, although sudden dilatation has been observed to take place during the course of an operation and can usually be promptly and completely relieved by appropriate measures. The symptoms are liable to develop insidiously. The most striking feature, perhaps, in the clinical picture is the frequent vomiting which cannot be otherwise explained. The patient does not strain much during the vomiting, but rather regurgitates without effort. The pulse-rate increases and there may soon be symptoms of collapse. An unquenchable thirst is often a prominent symptom. The patient looks ill and the whole picture impresses one with its seriousness. A curious feature that has been observed at times is the fact that although the stomach may be enormously distended there may be no

visible distention of the abdomen—indeed, it may be retracted. The amount of urine is always markedly diminished.

Among the etiological factors supposed to favor the production of acute dilatation of the stomach are:

1. Operations under general anesthesia.
2. Severe or prolonged and wasting diseases.
3. Indiscretions in diet.
4. Diseases or deformities of the spine.
5. Thrombosis.
6. Visceroptosis.
7. Large abdominal tumors.

Moynihan reports 12 cases out of 44 in which the dilatation was not limited to the stomach but involved the duodenum also, and in one case the upper few inches of the jejunum. Box and Wallace think there is perhaps first a paralytic condition of the stomach leading to distention and then pressure on the duodenum where it crosses the spinal column by the heavy distended stomach, producing obstruction.

Some observers think the distention due merely to excessive secretion, while others believe it to be the result of a spasm of the pylorus.

Albrecht was the first to suggest that the constricting agent may be the superior mesenteric vessels which, owing to the downward dragging of the intestines, press upon and obstruct the duodenum as it crosses the spinal column. This explanation is favored by the majority of writers, but it certainly does not explain all cases, as the writer has had occasion several times to observe at operation that the mesenteric vessels were not at all taut nor the duodenum compressed while the stomach was enormously distended.

It has been shown experimentally that section of the pneumogastric nerves in a dog is followed by dilatation of the stomach.

In acute dilatation occurring postoperatively, frequently the first symptom to be observed is a sudden increase in the number of heart beats per minute and great difficulty in breathing. Physical examination demonstrates marked upward displacement of the heart which is corrected immediately upon the introduction of a stomach-tube with the rapid, noisy expulsion of gas through the tube.

Treatment.—As soon as this condition is recognized, or indeed as soon as its presence is suspected, the stomach-tube should be passed and care taken that the stomach is entirely emptied. Owing to the loss of muscular tone of its walls, this must usually be done by siphonage or gravity. It is well to attempt to stimulate the muscle by irrigating with very warm water or salt solution, our practice being to use a temperature of 110° F. The foot of the bed should be elevated and if possible, the patient turned on his side or abdomen. The stomach should be irrigated as often as is necessary, preferably every hour until its tone is restored and the obstruction relieved. This may be a matter of several days. Operative procedures, such as gastrotomy and gastro-enterostomy, are not indicated and not to be performed; at

any rate, not until the continued use of the stomach-tube has been of no avail. Drugs appear to have little, if any, value in this condition.

A chronic form of gastric and duodenal dilatation has been described. The same pathological processes are supposed to be present and active as in the acute form, and the same treatment is to be employed. If the condition were always due to mechanical obstruction of the duodenum from taut mesenteric vessels a gastro-enterostomy ought always to give immediate and complete relief. Such, however, is not the case.

In acute gastric dilatation the patient should always be placed in a prone position at once unless a stomach-tube is immediately at hand because frequently this maneuver alone will bring prompt and permanent relief while the delay which may be occasioned by efforts to procure a stomach-tube may be sufficient to result in a fatal issue. The editor encountered one case in which a patient, aged forty-nine years, with partial occlusion of the coronary arteries died because of the sudden severe displacement of the heart before the acute dilatation could be relieved by the passage of a stomach-tube.

OPERATIONS ON THE STOMACH.

For convenience of description the stomach is divided into two portions, the cardiac and the pyloric. The axis of the cardiac portion is practically vertical, converging slightly toward the midline below while the axis of the pyloric part is almost horizontal. It is safe to say that three-fourths at least of the surgery of the stomach has to do with the pyloric portion. This is fortunate, both because of its accessibility and movability as compared with the cardiac portion. It will be observed that, as a rule, the more the symptoms from which relief is sought through surgery have their origin in obstructive processes about the pylorus the earlier will they manifest themselves and the more complete will be the relief from surgery. The converse of this proposition is also true, namely, that the further removed the pathological process is from the pylorus the less early do the resulting diagnostic symptoms appear and the less complete the relief experienced from surgical measures. It is also well to bear in mind that the more pronounced macroscopically and the more easily demonstrable the pathological lesion for the relief of which the operation is undertaken the more certain and complete is the subsequent relief. Of course, we are not including in this category inoperable cancerous growths. Where careful inspection of the stomach at the time of operation fails to reveal a definite, demonstrable lesion, further operation is contraindicated.

Surgery is of little avail in the so-called functional disturbances of the stomach, not infrequently it aggravates the symptoms.

It is assumed that the operator is familiar with the fundamental principles of aseptic surgery and the healing of wounds, and with the contents of the armamentarium of the abdominal surgeon. Time and space will therefore not be taken in order to describe the various

methods of intestinal suture and suture materials of which use is made in gastro-intestinal surgery. The same is true of the various special instruments, such as needles, stomach and intestinal clamps, retractors and the like. When occasion is had to refer to any of them they will be called by name without further description of their individual characteristics.

In the consideration of the surgery of the stomach it should not be forgotten there is a vast range of pathological conditions that have their origin outside of the stomach; indeed, many of them entirely outside of the abdomen, which not infrequently present as one of their earliest manifestations nausea and vomiting, or some form of gastric disorder or distress. Every effort, therefore, should be made to arrive at a definite and correct diagnosis before surgical measures are resorted to, in order to avoid making the grievous mistake of an unnecessary operation. There is no class of cases in which it can be more truly said that the combined skill of the physician and surgeon is productive of better results—indeed, is so absolutely necessary—as in the case of suspected disease of the stomach. Hearty coöperation, therefore, between the physician and surgeon in the diagnosis and treatment of this class of cases is most desirable. The writer never operates upon a patient suffering from supposed stomach trouble without first having him thoroughly studied out and reported upon by a competent internist, and then not until he has satisfied himself that no further improvement is to be expected from a continuance of medical measures. While it is undoubtedly true that many cases of "stomach trouble" suffer for lack of surgical treatment, or from such treatment having been too long deferred, it is equally true there is a great deal of unnecessary and unjustifiable operating being done upon the stomach. The chief offenders in this respect, perhaps, are those occasional operators who, by reason of defective training, lack the judgment and skill necessary properly to perform operations upon the gastro-intestinal tract, and without which they should never be undertaken.

When a surgeon is consulted by a patient with the history of some gastric disorder he is confronted with the necessity of making a decision, sooner or later, upon four points: (1) the diagnosis, (2) whether the case can better be treated by medical or surgical measures, (3) if surgical the character of the operation indicated and (4) the manner in which such a surgical operation is to be performed. This includes a consideration of the proper preparation and care of the patient, both before and after operation. Concerning the first of these questions, namely, "diagnosis," we are not especially concerned in this chapter; for it has been ably presented in the preceding one. But one should never for a moment lose sight of the fact that the diagnosis in any given case of stomach trouble is not only not always easy, but it not infrequently happens that it must be left to be determined at the autopsy or by the exploratory incision of the surgeon, a rather humiliating confession in these days when through the *x*-rays, the laboratory and other special tests, our diagnostic ability in general has reached such a high state of

scientific development. A supposed stomach case may, after careful consideration, prove to be almost anything from tabes or an inflamed appendix to a brain tumor.

Before considering the choice of operation in a given case of gastric disorder, it is well to determine first whether or not any operation is really necessary. The persistence and severity of the symptoms and the progressive nature of the disease, together with the failure of properly applied medical measures to afford relief, are the factors which decide this question in the affirmative. One should then consider what it is expected to accomplish by the operation. Is it to be simply a palliative procedure undertaken to give temporary relief to the patient or are we justified in expecting and offering a cure? These are important questions which the patient is likely to ask, and when he does, he is entitled to an honest and intelligent answer. Upon what basis, too, are we going to determine the operative procedure to be carried out? Is it to be on the basis of habit, because we are all more or less creatures of habit, or is it to be a matter of fashion, because there are fashions in surgery just as in dress; or is every individual case to be decided upon its own merits and due weight to be given to the relative advantages or disadvantages that are generally accepted as belonging to any particular type of operation? The surgeon ought to have a valid reason for every operative procedure that he undertakes, and should be able successfully to defend his position.

Except in cases of emergency no operation should be performed on the stomach or duodenum without adequate preliminary preparation of the patient. Cushing has shown that it is possible, through sterile feeding and antiseptic mouth washes, to render the stomach and upper portion of the intestinal tract sterile. These observations have been abundantly confirmed by our own clinical experience. Likewise, no surgical operation should be undertaken, except in case of emergency, without proper attention to details of technic, asepsis, competent assistants, suitable instruments, etc. These facts are so fundamental that it seems hardly necessary to call attention to them. As regards the details of the technic of a given operation on the stomach, they vary largely with the operator. This is true also of the different instruments, such as stomach clamps, etc., that are to be used; but too much care cannot be taken in matters of detail, as not infrequently the ultimate result is determined by the conscientious manner in which these are carried out by the operator and his assistants. The question of the anesthetic and of the skill with which it is administered should never be overlooked. Here, again, individual methods differ, but there are certain fundamental rules which are common to all and which should never be disregarded. Crile's anoci-association as practised in his clinic commends itself to careful consideration. Local anesthesia seems to be gaining advocates, particularly on the continent, but for stomach operations it does not seem to be as well suited as for certain others.

In the after-care of all cases of operation upon the stomach the most effective agents at our command are the use of the stomach-tube and

proctoclysis by the method of Murphy. These are two of the most efficient life-savers contained in the armamentarium of the surgeon. The addition of lactose and bicarbonate of soda to the fluid to be injected adds much to its efficiency by lessening the dangers of acidosis and by improving the nutrition. The complications that may follow operations on the stomach and duodenum are those common to all abdominal operations and need not be referred to in detail. All the time, as our knowledge increases and our technic becomes simpler and more effective, these accidents of operation are becoming less and less frequent, until now one undertakes a major operation upon the stomach with a feeling that borders on assurance. Lung complications will never be completely abolished so long as we have to use anesthetics. Secondary hemorrhage and peritonitis are usually the result of faulty technic and, as such, are gradually being eliminated. Acute dilatation of the stomach can be recognized if watched for and may be controlled by the early and continued use of the stomach-tube. Phlebitis and thrombosis are always serious when they occur, but, fortunately, their occurrence is rare. They cannot as yet be entirely prevented but careful handling of the tissues and the control of sepsis seem to tend very materially toward lessening the frequency of their appearance. The different forms of anemia certainly are in some way concerned in the production of thrombophlebitis, as one or other of them is almost always found to be present.

As regards drainage, in general the tendency seems all the while more directed against the use of drainage of any kind, except in cases in which pus or extravasation of intestinal contents are actually present. In operations on the stomach and duodenum this is rarely the case. Hence it is very seldom that it will be found necessary to drain the wound. The exception to this is usually in cases of perforation. Here, not infrequently, it will be found to be good judgment to drain at least to the neighborhood of the perforation after closure. A drain applied directly to the suture line will almost surely be followed by a gastric fistula.

The stomach in health varies within very wide limits as regards its size, shape and position, depending largely upon the age, sex and habits of the individual and upon the amount of food or drink which it contains. Under pathological conditions these variations may be much wider and its position and relation to surrounding structures may be very far from normal, depending in turn upon the nature of the pathological processes present, either in the stomach itself, the neighboring viscera or the abdominal walls. Generally speaking its long axis is inclined obliquely downward and to the right from the cardiac orifice, which is its only fixed point. This axis in turn varies from almost vertical to the horizontal. The pylorus from being a movable point within certain physiological limits, may become firmly attached by adhesions to the under surface of the liver, the gall-bladder, the colon or the abdominal wall. On the other hand, the pylorus is occasionally seen so freely movable that in extreme cases it may be displaced

into almost any region of the abdomen. In thin individuals with relaxed abdominal walls the pylorus when contracted may at times be readily palpated as a small, firm, rounded and movable mass. The lymphatics of the stomach are of great importance in relation to cancer. In general the main lymphatic channels and lymph nodes are to be found along its upper and lower borders, closely associated with the course of the bloodvessels. The pyloric one-third of the greater curvature and the whole of the lesser curvature of the stomach are the portions most richly supplied. This fact should always be borne in mind in planning an operation for cancer.

The blood supply of the stomach is obtained almost entirely from the celiac axis. The main arterial trunks come in at the four corners, as it were, and run along the greater and lesser curvatures, sending branches at frequent intervals to the walls of the stomach in front and behind. At the left end of the lesser curvature comes in the gastric or coronary artery. After sending small branches to the cardiac end it traverses the lesser curvature from left to right until it anastomoses with the pyloric artery, a branch of the hepatic. Still another branch of the hepatic, the gastroduodenal, passes down behind the pylorus and forms the right gastro-epiploic, which, traversing the greater curvature toward the left, finally anastomoses with the left gastro-epiploic, a branch of the splenic which comes out from behind the stomach and also sends a smaller branch to the fundus and cardia. The veins closely accompany the arteries and anastomose freely with one another.

The Incision.—Although a variety of incisions have from time to time been suggested and advocated by various operators, the one incision which seems the most free from objection and the one best suited, perhaps, for any particular operation is through the right rectus. Separating, as this does, the fibers of the muscle parallel to their course, it cuts across no important structures, does not seriously impair the nerve supply, provides good exposure of the contents of the upper right quadrant and is followed by excellent repair. It is seldom that one sees a hernia develop through the rectus muscle unless there has been suppuration, with considerable sloughing of tissue. Various other incisions have their advocates. Of late the transverse incision has come into prominence, but possesses no real advantage over the right rectus and some obvious disadvantages. The methods of closure are also of the greatest importance. The suture material, its character, whether absorbable or non-absorbable, methods of sterilization, etc., have all been the subjects of controversy; but it will be found in the last analysis that the best test of one's technic is one's ability to use silk without trouble. With a perfect asepsis one finds no trouble from the use of fine silk for sutures and ligatures. With a doubtful technic it is always best to use absorbable suture material. Too much emphasis cannot be laid on the gentle handling of tissues, upon clean-cut dissection with a sharp knife and upon the avoidance of mincing tissues by numerous small cuts, as in the dissecting room. Every cut of the

knife should be utilized to the full. The mauling of tissues with retractors, the crushing of large masses with heavy clamps and tight suturing all tend to disturb the quick and satisfactory healing of wounds. These are the factors that not infrequently determine whether a wound will heal by first intention or by granulation, whether it will suppurate or not. The rough handling of tissues not only interferes with the healing of the wound but adds materially to the shock of the operation and the after-discomfort of the patient. In closing wounds careful apposition of tissues should be secured. Interference with the circulation in the wound edges by too tight ligatures or sutures should be studiously avoided. If these cardinal rules are scrupulously observed all that is needed to secure good healing of the wound is proper coaptation of the wound edges and holding them in this position. Bulky dressings and uncomfortable, rigid bandages are not necessary. Light dressings that allow of freedom of movement will be found to add greatly to the patient's comfort and to detract nothing from the wound healing.

Gastrotomy.—The operation of gastrotomy has a variety of uses. It consists simply in making an incision through the wall of the stomach into its lumen. Other things being equal this should always be made parallel to the blood supply and usually through the anterior wall. If the stomach has been previously prepared it can be carried out with little or no risk of infection. Through this incision the interior of the stomach can be thoroughly inspected and examined, and instruments or the hand passed into the interior in order to explore it or through it to examine adjacent structures, such as the esophagus or duodenum. The writer has in this manner removed sets of false teeth, peach-stones and other foreign bodies from the lower segment of the esophagus. Through this incision it is possible to perform transgastric resections of the posterior stomach wall, to excise or treat ulcers, stop hemorrhage, etc. Afterward the stomach wall is to be closed by two rows of continuous fine silk sutures or a single row of interrupted mattress reinforced by Lembert sutures.

The operation of gastrotomy is the basis of practically all of the operations upon the stomach, because the vast majority of them have to do with the opening of its lumen. This opening may be closed at once or it may be kept open and the operative procedure changed into a gastrostomy, according to the indications present.

The points of fundamental importance in all operations upon the stomach are careful preliminary preparation of the patient, sterile feeding, gastric lavage, an empty stomach, good anesthesia (preferably ether, administered by a competent anesthetist), absolute asepsis and the careful protection of the abdominal cavity and viscera by walling off the field of operation with gauze pads wrung out of warm normal salt solution. This can only be satisfactorily carried out through an abdominal incision of ample length. The careful handling of tissues, non-use of retractors, avoidance of rough sponging, etc., absolute hemostasis, accurate apposition of tissues in wound closure and the

absence of tension in sutures or ligatures are essential in securing the best results. The covering-in of all raw surfaces with omentum limits the formation of peritoneal adhesions that may subsequently prove troublesome.

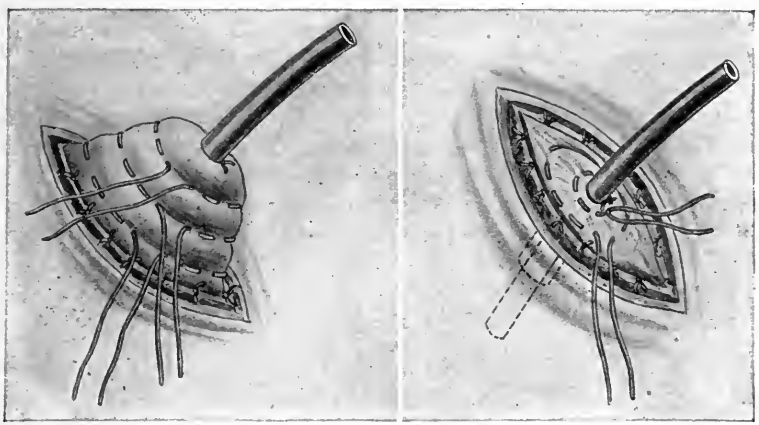


Fig. 282 Fig. 283

Figs. 282 and 283.—Gastrostomy. E. J. Senn's method. (Keen's Surgery.)

Gastrostomy.—In the operation of gastrostomy, the object is to make a permanent fistulous opening into the stomach for the purpose of administering nourishment. The chief indication for the operation

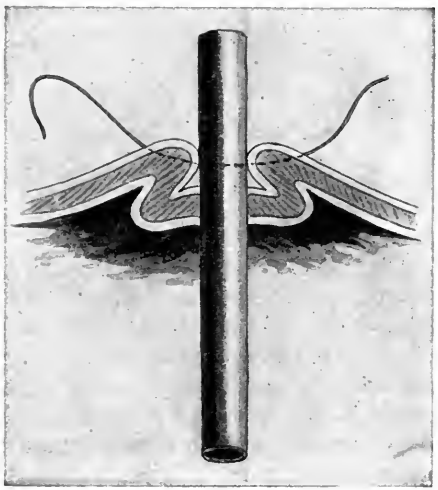


Fig. 284.—Gastrostomy. Kader's method. (Keen's Surgery.)

is an obstruction to the normal passage of food through the esophagus. The objections to the operation are obvious. The idea is abhorrent to the patient, and not infrequently the method of administration of

food disgusting; but even under these unfavorable circumstances it has its place and plays an important part in the surgery of the stomach. In the majority of cases in which the operation is done, cancer is the cause of the esophageal stenosis; hence these patients are always more or less starved out and make poor surgical risks. The mortality is therefore unusually high compared with other operations. There are various methods by which the operation may be performed. The end that all strive to attain is the prevention of the escape of gastric contents through the fistula, and thus the avoidance of the resulting irritation of the surrounding tissues due to the presence of the gastric juice. Not infrequently these patients are in such poor physical condition that it is better to do the operation under local anesthesia. Wherever it is possible the patient should be prepared for operation

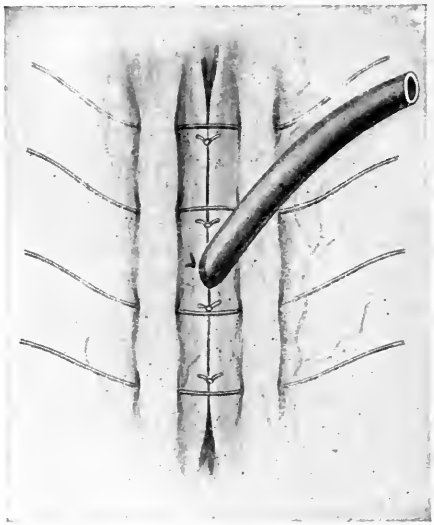


FIG. 285.—Gastrostomy. Kader's method. (Keen's Surgery.)

by preliminary feeding through a small esophageal tube passed through the stricture and kept in place for days at a time, if need be, as suggested by Moynihan. The writer has found more satisfaction from the use of the methods of Witzel and Franck than any other, although the methods of Senn and Stamm-Kader, which are practically the same, are advocated by many surgeons. The Franck operation is a little more complicated than the others, and in cases in which the stomach is small and its walls thickened and contracted it will not be found as satisfactory as the other methods. It is performed as follows:

An oblique incision is made parallel to and about one inch below the costal margin on the left side. The peritoneum is exposed and opened at the outer border of the rectus muscle. A second short incision is then made parallel to and over the costal margin about two inches dis-

tant from the original incision. The skin and fascia and some muscle fibers between these two incisions are then elevated from the costal margin by a blunt instrument, such as curved scissors or periosteal elevator. A cone of stomach is then picked up and brought out through the original wound and passed under this bridge of tissue and the tip brought out through the second incision and stitched into place by

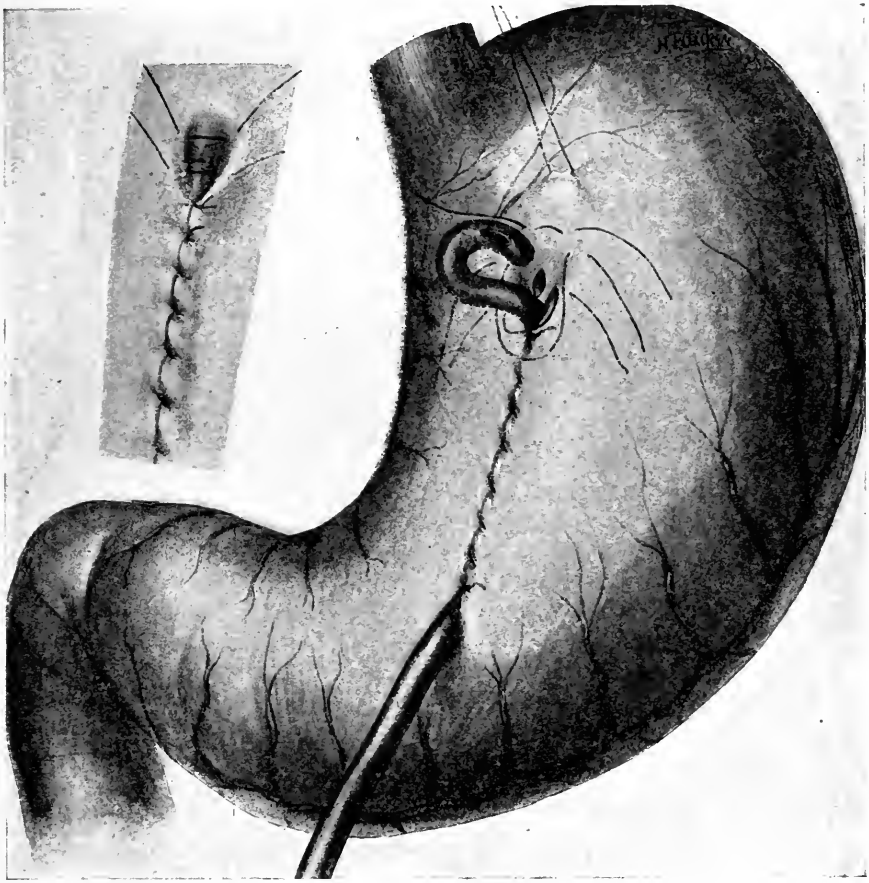


FIG. 286.—Witzel's gastrostomy. Catheter partly buried in stomach. Guide stitch above opening. Interrupted stitches placed before inserting point of catheter. The eye of the catheter has been inserted within the stomach. Interrupted stitches ready to tie. (Gould.)

sutures, attaching the stomach (1) to the peritoneum and (2) to the edges of the second incision. In this way an angle is produced by the cone of stomach being drawn over the costal margin, and, in addition, the two walls of the stomach are held into close apposition by being clamped, as it were, between the overlying bridge of soft parts and the costal border. The canal leading into the stomach is thus rendered

oblique and kept closed. The original wound is then closed by sutures. The tip of the cone which projects through the second incision can be opened when needed and a catheter passed through it into the stomach for the purpose of feeding.

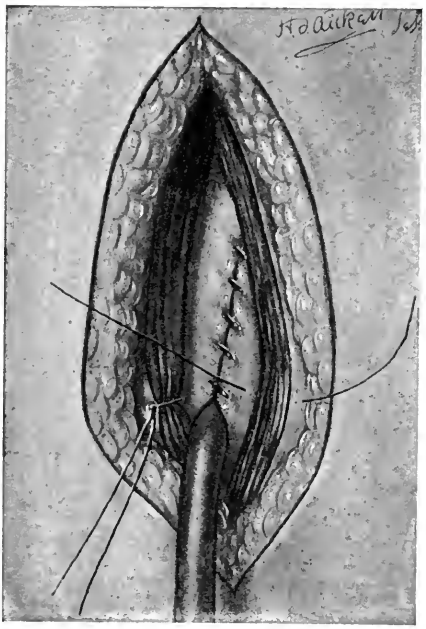


FIG. 287.—Witzel's gastrostomy. Stomach fastened to anterior abdominal wall by interrupted stitches. These stitches penetrate all layers, including the anterior rectus fascia. The ends are left long to assist in removal, later. (Gould.)

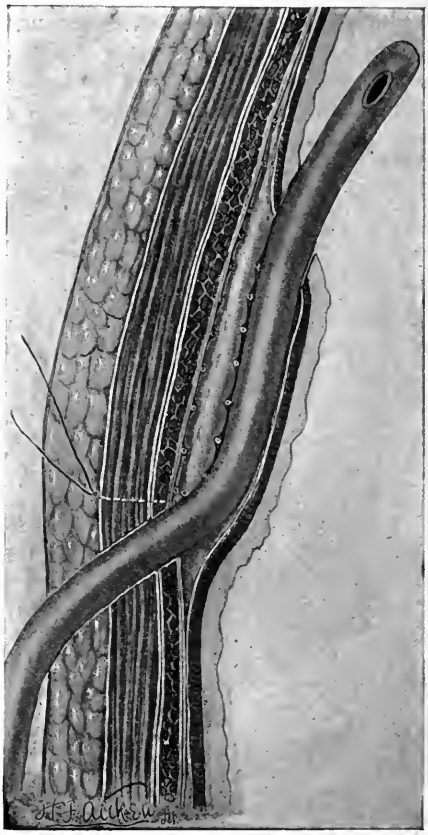


FIG. 288.—Witzel's gastrostomy, cross-section. Eye of catheter is in the cavity of the stomach. Note the various layers through which the catheter passes. (Gould.)

The Witzel operation is usually performed by an incision through the left rectus. The stomach is exposed and a small incision made through its walls just large enough to admit a soft-rubber catheter about No. 25 French. The rounded end of the catheter is introduced into this opening the other is closed by a clamp to prevent leakage. The catheter should then be fixed to the gastric wound by one or more catgut sutures, then with a continuous catgut suture the stomach wall is folded closely around the catheter for a distance of one and a half to two inches. Several rows of sutures can be taken over the catheter,

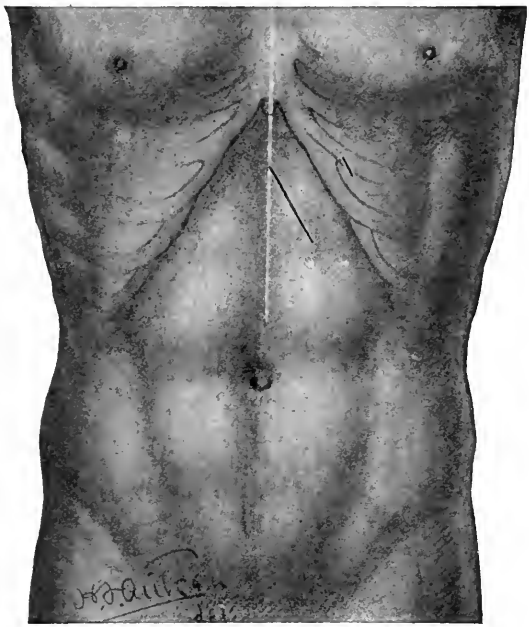


FIG. 289.—Ssbanajew-Franck gastrostomy. Incision lines. (Gould.)

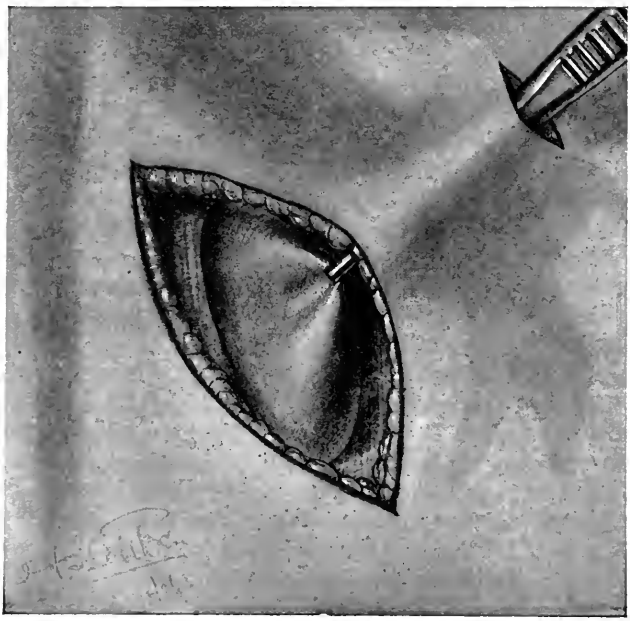


FIG. 290.—Ssbanajew-Franck gastrostomy. Bridge of skin dissected up. The cone of the stomach is being pulled beneath bridge. (Gould.)

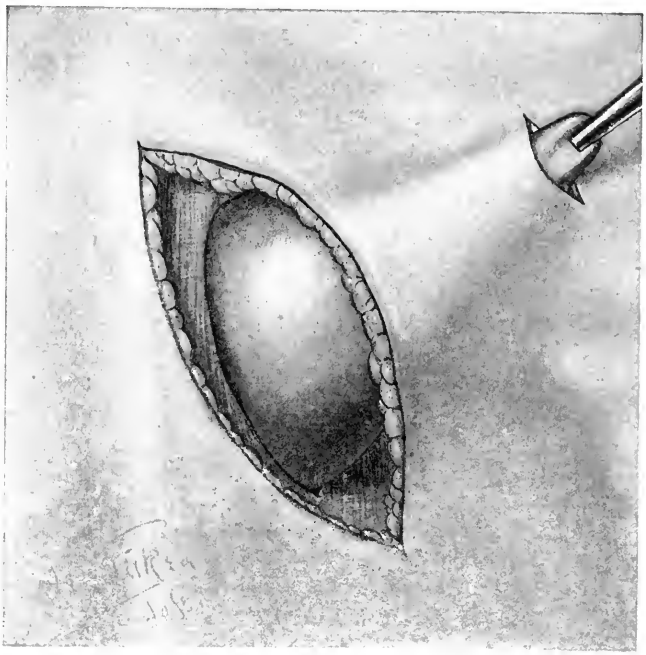


FIG. 291.—Ssbanajew-Franck gastrostomy. Cone of stomach held in place with forceps. The base of the cone fastened to the peritoneum with interrupted stitches. These stitches are only visible in the cross-section. (Gould.)

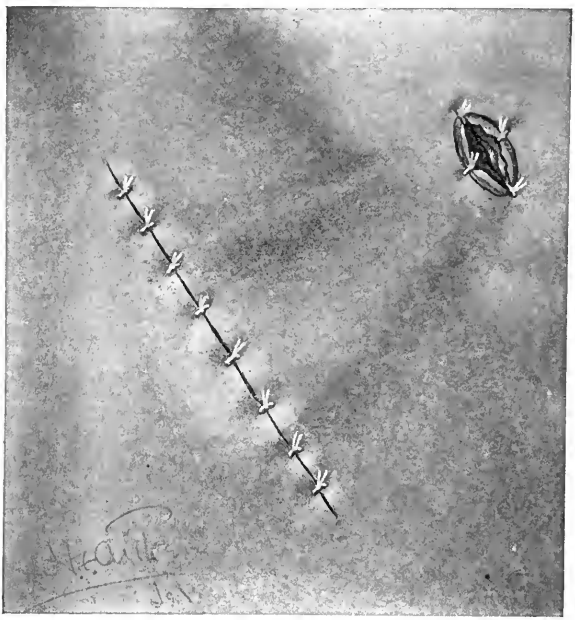


FIG. 292.—Ssbanajew-Franck gastrostomy. Skin closed over base of cone. Apex of cone opened and sewed to skin. (Gould.)

thus approximating wider surfaces of the stomach wall. A canal is thereby formed through which the catheter passes into the stomach. The edges of the outer opening of the canal should be sutured to the parietal peritoneum. The free end of the tube projects through the abdominal wound which is united closely around it and to which it is sutured by a fine silk suture, in order to avoid traction or the slipping of the tube into the stomach.

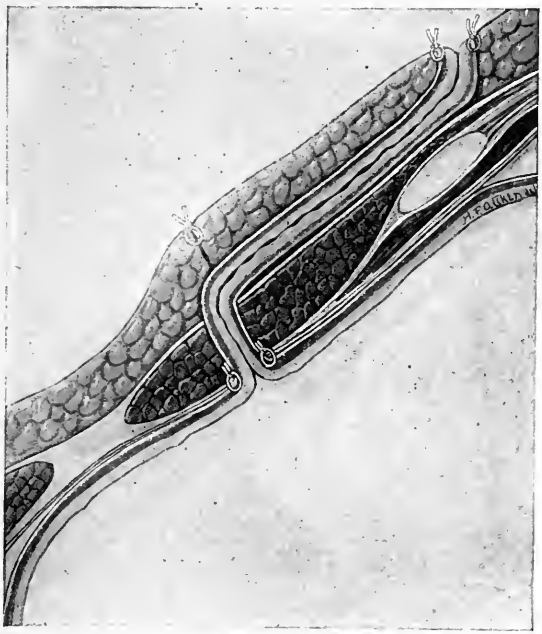


FIG. 293.—Ssbanajew-Franck gastrostomy. Cross-section. (Gould.)

The object of the Stamm-Kader operation is to provide a valvular opening into the stomach by inverting into its lumen a cone of the stomach wall. This is done by fixing the tip of a catheter into a small opening in the stomach wall, as in the first step of the Witzel operation, then, by means of the catheter, inverting a cone of the wall and suturing it in successive layers (continuous in the Senn method, interrupted in the Stamm-Kader) about the catheter, until a valve-like canal one and a half inches or more in depth has been formed. The wound is then closed as in the Witzel method.

Any of these methods will give fairly satisfactory results. In all of them, sooner or later, there is liable to be some leakage from the fistulous opening, a tendency for the canal to shorten or, in the Franck operation, for the two openings gradually to become opposed by the shortening and straightening of the canal. The method suggested by Janeway aims to construct out of a flap from the stomach wall a tube lined with mucous membrane. It has the advantage that this tube

does not tend to contract to any great extent, but it also has the disadvantage that it is more complicated than the other methods and is only applicable when the gastric wall is soft and pliable and the stomach not too contracted. The operation is somewhat along the general lines of the Heineke-Mikulicz operation by pyloroplasty. A rectangular flap one and three-fourths by one-half inches, with its long axis corresponding to the long axis of the stomach is turned up. The stomach wall is folded upon itself and the short sides of the parallelogram are opposed to each other and sutured together, as are the edges of the everted flaps of the gastric wall, thus forming a tube about two inches long lined with mucosa. This tube is then brought out through the abdominal wound and its base sutured to the parietal peritoneum and the margin of the rectus sheath and its tip to the skin edges. If desired the base of the tube may be inverted into the lumen of the stomach in order to form a valve, as in the Stamm-Kader operation.

Gastroplication.—This operation, while it has been performed a few times by various surgeons, certainly has a very limited sphere of usefulness. The idea of the operation is unscientific and unsurgical and its performance is seldom if ever justified. As the name implies it has to do with the lessening of the size of the stomach in cases of marked chronic gastric dilatation. As described by its advocates it consists in the introduction into the anterior wall of the stomach of several rows of continuous sutures of any desired variety. These sutures are placed more or less vertically and passed from the greater to the lesser curvature. When they are tied the anterior wall of the stomach is turned in upon itself into several folds, thus reducing the caliber of the stomach, but having no other effect. The operation has nothing to commend it.

Gastropexy.—Notwithstanding the fact that the operation of gastropexy has received the sanction of a number of well-known surgeons, still, there are so many objections to it that it is of very doubtful utility. In the first place the sagging of the stomach is usually but one manifestation of a general enteroptosis. The question naturally arises, "If this is the case, what benefit can be derived from suspending the stomach and paying no attention to the rest of the displaced viscera?" In the second place the majority of these patients are of the profoundly neurotic type in whom, as a class, surgery offers the least hope of relief. There are obvious disadvantages to any fixation of the stomach, either to the anterior abdominal wall or to the liver, or to any other more or less fixed structure, because the stomach in performing its physiological function is continually changing its size and position, and anything which tends to restrict these motions is liable to be followed by discomfort to the patient and a disturbance of the gastric function. The indications for the operation are therefore certainly limited, and one should hesitate before performing it, especially until after having tried the effect of massage, postural treatment and external mechanical supports, from the use of which very satisfactory results can sometimes be obtained. The original idea of the operation, as suggested by Durst, was to fix the stomach at its upper border along the lesser

curvature to the abdominal wall, approximately, in its proper position. This was done by suturing the peritoneum of the upper portion of the wound, after stripping it away from the shealths of the recti to the lesser curvature of the stomach. The suture was a continuous one of silk passed horizontally through the various coats of the abdominal wall on the one hand, and the serous and muscular coats of the stomach on the other. Rovsing reports a long series of cases which he has operated upon by a method which consists in passing three or four parallel silk sutures horizontally through the outer coats of the stomach. The ends of the sutures are tied over a gauze pad or over a glass rod after having been passed through the entire thickness of the abdominal wall. Although he reports good results from his operation, it strikes one as being rather crude and open to serious objections.

The operations of Coffey and Beyea are less objectionable than the preceding methods, because they do not fix the stomach to the abdominal wall, while at the same time furnishing it an additional support. The idea of Coffey's operation is to fix the omentum along the greater curvature to the abdominal wall along a line above the level of the umbilicus.

This is done by ordinary sutures. The stomach proper is not adherent to the abdominal wall, and more play is in this way allowed.

Beyea, by plicating the gastrohepatic and gastrophrenic ligaments and thus taking a reef in them, as it were, hopes to accomplish the end desired without incurring the objections raised to the other methods. Several rows of mattress sutures were introduced. It is desired thus to elevate the stomach a little above the normal. This operation is facilitated by the use of the Trendelenburg position.

It is conceivable that, under certain circumstances, gastroplication may be indicated, but they certainly are rare. The cases in which any of these procedures are to be performed should be selected with the greatest care.

Gastric Adhesions.—It not infrequently happens that the surgeon is called upon to perform operations upon cases which, owing to previous inflammatory or ulcerative conditions, or following surgical operations of one sort or another, have become the subject of dense and extensive adhesions. Why it is that one case will present well-organized fibrous adhesions and another will not, after apparently similar conditions of peritoneal irritation, has never been satisfactorily explained; or why it is that dense adhesions in one individual will produce no appreciable disturbance, while in another similar adhesions, or those much less marked and extensive, will give rise to a great deal of discomfort and annoyance. There are few conditions in the proper management of which a greater amount of surgical judgment is called for than in the treatment of abdominal adhesions. It will be found to be an extremely difficult matter to decide just which cases are suitable for operation. Not infrequently, to separate dense, well organized adhesions, and to dig out the different organs without subjecting them to rough handling or severe injury, is a practical impossibility. The

problem is to free the organs from distorting adhesions without undue trauma, and then to limit or prevent, so far as possible, their subsequent formation. Up to the present time comparatively little has been accomplished in this direction. Various solutions, foreign substances, etc., have been advocated from time to time, but with little success, so that none of them are to be recommended. The means at our disposal which seem to offer the best results are the use of the omentum interposed between surfaces which it is desired to prevent from adhering to one another. While the omentum, of course, remains adherent to the raw surfaces with which it comes in contact, it is a movable structure and allows considerable play in muscular, respiratory and other physiological movements. The writer has had abundant opportunity to observe the satisfactory results following its use in this way where it has been available. Unfortunately it cannot always be so used. Frequent changing of the position of the patient, high elevation of the foot of the bed, setting the patient upright, rolling him from side to side, the early administration of cathartics in order to excite peristalsis, and massage, all these measures when applied early, before adhesions have had the opportunity to become thoroughly organized, undoubtedly exert a beneficial effect. There is no special method of separating adhesions further than experience has taught that it is far easier and safer to work from within out rather than from without in. In other words, if the operator will extend his incision until he has opened the general peritoneal cavity beyond the adherent area, then passing a finger or, better, the whole hand into the cavity through the abdominal incision and behind the adhesions, pulling them forward into the incision, he can thus better identify and separate the different structures the one from the other. After all the adhesions have been carefully separated the omentum can then be wrapped around or laid over the surface to be protected and held in place by a few sutures. These latter are usually not necessary if care is taken in the closure of the abdominal wounds not to disarrange the omentum. Subsequent to the operation the frequent change in posture of the patient should not be neglected. A great many of the discomforts subsequent to operations upon the stomach are ascribed, whether rightly or wrongly, to the formation of adhesions, and many secondary operations are performed for the relief of these adhesions. It is questionable just how much discomfort ordinary adhesions may cause, but there is no reason to doubt that they do play a more or less important part in preventing the securing of a perfectly satisfactory result. Every effort, therefore, should be made by careful and painstaking attention to the details of operative technic in order to limit, so far as possible, the formation of postoperative abdominal adhesions. A very considerable percentage of gastric surgery has to do with the separation of these adhesions, a fact that should be borne in mind. It is a good plan always, where possible, to cover all suture lines in the stomach and intestines with omentum for two reasons: (1) it fortifies and renders more secure the suture line and (2) it prevents the formation of adhesions between two

more or less fixed structures, a condition which very materially conduces to postoperative discomfort, which often means just the difference between a result that is perfectly satisfactory and one that is not.

Gastrectomy.—The operation of gastrectomy may be partial or complete. The indications for the former are tumor of the gastric wall or ulcer. The operation is to be carried out just as in the case of gastrotomy. Hemorrhage is to be controlled and the suture made, after removal of the resected portion, just as in gastrotomy. There is one precaution to be observed in all resections of portions of the gastric wall, namely, the incisions should always be made transversely so far as possible. Especially is this true of the line of suture as a longitudinal closure tends to narrow the lumen of the stomach and may give rise to a subsequent hour-glass constriction of its walls.

Ulcers situated upon the posterior wall of the stomach were, until recently, considered beyond the reach of direct surgical treatment. The advocacy by W. J. Mayo of the so-called transgastric route for the direct access to these ulcers has, to a certain extent, popularized this method. Through a vertical incision in the anterior wall of the stomach the ulcer on the posterior wall is examined and then excised from within out. Mayo advises the removal of a slice of pancreas if it is found to be densely adherent to the base of the ulcer. Care should be taken in the closure of the posterior wall with, first, a serous and then a through-and-through chromicized catgut suture from the inside of the stomach. The anterior wall is then sutured as in ordinary gastrotomy. The writer has not always found it advisable to resect ulcers on the posterior wall of either the stomach or duodenum. The method that he has frequently employed is through his usual pyloroplasty incision in the anterior walls of the stomach or duodenum to carefully inspect the ulcers upon the posterior wall of either viscus, as the case may be, by lifting up the posterior wall into the wound, on the fingers of the left hand from behind. The base of the ulcer is then incised with multiple crucial incisions just as one treats a chronic indolent ulcer of the leg or elsewhere. The overhanging mucous membrane around the edges of the ulcer is then carefully trimmed off to make the edges of the ulcer flat and thus hasten its healing. Hemorrhage is then stopped and the edges of the ulcer folded upon themselves by catgut sutures. Ulcers treated in this way seem to do better than when untreated, at least the symptoms of pain, indigestion, etc., seem to subside more rapidly and completely under this treatment than without it. No opportunity has as yet offered to examine post mortem an ulcer so treated, as they have all recovered.

Complete gastrectomy has only been performed a few times and will rarely be found to be justified, as it is not indicated where there is extensive involvement of neighboring structures, a rare condition where the stomach itself is so much involved as to suggest this operation. The chief points to be borne in mind in performing the operation are an incision sufficiently ample to insure good exposure of the parts. Free the stomach thoroughly by division of all adhesions, and of the

greater and lesser omenta. Divide the esophagus, after clamping it off as high as possible. Divide the duodenum between two clamps. It will usually be found easier to anastomose the end of the esophagus into the side of the jejunum after closure of the duodenum, rather than to unite the cut end of duodenum and esophagus end to end. The toilet of the peritoneum and the closure of the abdomen are the same as in gastrotomy.

The most important point in this operation lies in the prevention of tension. A portion of the jejunum should be chosen a sufficient distance below its origin to prevent tension.

Excision of Gastric Ulcers.—Considerable difference of opinion exists at the present time as to the advisability of excising gastric ulcers. Some surgeons make a practice of excising them whenever possible. Those who favor excision cite the frequency of the occurrence of malignant degeneration following ulcerative processes in the stomach as sufficient indication for the removal of the ulcer whenever it is possible. There would seem to be considerable force in their argument, especially since the scars of apparently healed ulcers seem to be not entirely free from the possibility of becoming foci for the development of cancer.

On the other hand, those who do not make a practice of excision of ulcers oppose it upon the ground that it is unnecessary and a useless complication of the more typical operations.

While it cannot be denied that malignant degeneration is a fairly common complication of chronic gastric ulcer, it is also equally sure that many cases of chronic ulcer are curable by properly applied surgical measures. There remains then that relatively small number of cases in which the cancer has developed at the site of the supposedly healed ulcer. From the available statistics it would seem as if these constituted a sufficient number to make excision advisable whenever feasible. Other things being equal, therefore, excision of ulcers is recommended as a routine practice. They may be excised through an ordinary gastrotomy incision or through an elliptical incision, including the ulcer. One of the special advantages of the writer's pyloroplasty operation is the opportunity which it affords for the excision of ulcers situated on the anterior wall of the stomach or duodenum. Ulcers situated in this locality are very readily treated by excision because of their accessibility and the mobility of the anterior walls in general. Those situated on the lesser curvature or the posterior wall offer more difficulties, especially when adherent, as they not infrequently are, to adjacent organs. For the treatment of these forms several methods of procedure have been suggested. Transverse resection of the stomach for ulcer has the sanction of such authorities as von Eiselsberg, Perthes and Enderlen. They report very satisfactory results in quite long series of cases, both as regards immediate mortality (several series without a death) and subsequent functional results. In addition to this, *x*-ray examination showed apparent cure with contracted but quick emptying stomachs. The operative pro-

cedure is the resection of a zone of stomach wall containing the ulcer, much as in the case of hour-glass stomach, with careful hemostasis and suture, first of the posterior and then of the anterior gastric walls, as in any other form of resection.

Rodman's operation, or the resection of the ulcer-bearing area, has much to be said in its favor. It is a rather radical and probably unjustifiable procedure for routine practice, but when reserved for those patients whose physical constitution is good, or where, as suggested by Mayo, the possibility of cancer becoming later engrafted upon the ulcer seems to amount to a probability, it is a very valuable procedure. It is performed as an ordinary pyloric resection. The excision of the gastric wall should be sufficiently wide to include the whole of what Rodman calls the "ulcer-bearing area." Instead of using the Billroth No. 2 method of anastomosing the stomach, it will probably be better to use the newer method of Polyea.

Transgastric Resection.—This operation, advocated by W. J. Mayo, has been found to be satisfactory in the treatment of ulcers on the posterior wall of the stomach. As the name implies the anterior wall of the stomach is incised, as in ordinary gastrotomy. Through this incision the ulcer on the posterior wall is excised, together with a margin of healthy tissue. After careful hemostasis the rent in the posterior wall is closed from within with catgut sutures. If it is possible to expose the posterior wall sufficiently a few musculoperitoneal sutures may be used to reinforce those placed from within, although experience has shown that these are not actually necessary. If the base of the ulcer is formed by pancreatic tissue, Mayo recommends that the exposed surface be shaved off with a sharp knife or removed with the actual cautery. In such cases drainage should be provided by means of a small strip of folded rubber tissue carried down to the pancreatic lesion, which should also be protected, as far as possible, by omental grafts. While these cases do not often leak pancreatic fluid, it is safer to provide an outlet for it in case of need. It does no harm. The gastrotomy wound is closed in the usual manner.

Excision by Actual Cautery.—Balfour, from the Mayo clinic, recommends the use of the actual cautery for excisions of ulcers of the lesser curvature and in selected cases of duodenal ulcer as doing away with the possibility of hemorrhage. The gastrohepatic omentum is carefully dissected from the lesser curvature in the region of the ulcer. The ulcer is then burned through with the cautery point at a dull red heat and the whole area of the ulcer thoroughly burned out to healthy tissue. The opening is then closed with interrupted catgut and mattress-silk sutures. The reflected gastrohepatic omentum is then replaced over the line of suture and held there by a few fine silk stitches. Gastro-enterostomy is then performed as usual.

If it is true, as the statistics quoted by Mayo from European clinics seem to show, namely, that 32 per cent. of all deaths occurring among those who had had an operation previously for gastric ulcer were from

gastric cancer, and since many cases of supposed cure of ulcer following operation are not cured at all but simply a temporary cessation of symptoms has taken place, there would appear to be a good deal of force in his argument that if a permanent cure does not take place in a reasonable time under medical treatment, other things being equal, the patient should have the benefit of excision.

Pylorodiosis.—As in spastic contractions of the cardia, dilatation of the orifice by one means or another has been employed, so with the pylorus, but without such satisfactory results. The older methods of digital dilatation by invagination of the anterior gastric wall (Loreta's operation) or through a gastrotomy incision, have not been without danger, and the results have been such as not to warrant a further continuance of their use. They are not to be employed and are of only historic interest, and will, therefore, not be further described. Anyone interested will find them figured in the older text-books.

Pyloroplasty.—The indications for this operation are pyloric obstruction of a benign nature, from whatever cause, functional or organic. There are two general types of the operation described, the Heineke-Mikulicz and that of the writer. The former method, when performed as originally described by its authors, is attended with a fair degree of success; but as it was usually performed, it was later found that in a considerable number of cases the symptoms recurred. The reasons for this unsatisfactory condition were that the incision was usually made through the anterior walls of the stomach and duodenum and not the under surface, as recommended by the authors, and the original incision was not made sufficiently long to allow for subsequent cicatricial contraction of the new pylorus. For these reasons the operation fell into disrepute. The idea of the operation is to enlarge the caliber of the pylorus by converting a longitudinal incision through the pylorus into a transverse wound by sutures so placed as to bring together the two ends of the incision. It is performed as follows:

Heineke-Mikulicz Operation.—Through the usual right rectus incision expose and examine thoroughly the stomach and duodenum, freeing all adhesions. Bring the pylorus well out of the abdomen and pack off with gauze pads. Make a longitudinal incision through the under surface of the pylorus, continuing it in each direction well down through the gastric and duodenal walls. Stop all hemorrhage by ligature of individual vessels. Then bring the two arms of the incision together by opposing the gastric and duodenal walls, making a certain amount of angulation at the old pylorus. Complete the operation by suturing the cut edges of the opposing surfaces, preferably with mattress sutures, but with two rows of continuous sutures if so desired. It is well always to reinforce the suture line by wrapping loosely about it an omental flap. This has the additional advantage of preventing its becoming adherent to surrounding structures.

Finney's Operation.—In the writer's hands the results following pyloroplasty in benign stricture of the pylorus and in simple ulcer of the stomach and duodenum, especially when situated in the anterior

wall, have been, on the whole, decidedly more satisfactory than those following gastro-enterostomy. The mortality rate has been appreciably lower and the results have been more prompt and complete. Then, too, there always remains the opportunity to do a subsequent gastro-enterostomy if the pyloroplasty has proved unsatisfactory, a condition which has been observed in a small percentage of cases. Pyloroplasty has one distinct advantage over gastro-enterostomy, namely, that if it does no good it at least does no harm, a comforting feeling for the surgeon.

Objection has been raised to the term "pyloroplasty" by some writers on the ground that the operation is rather a gastroduodenostomy. While it is true of necessity that the operation brings about an anastomosis between the stomach and duodenum, still it has to do primarily with an increase in the caliber of the pylorus while a gastroduodenostomy does not necessarily disturb the existing pylorus in any way. The term "gastropyloroduodenostomy" would be a better descriptive term, but it is too cumbersome for common use. Hence, the original term has been retained.

Since this operation was first described by the writer in 1902 a number of similar methods or modifications of the original have been suggested (Narath, Jaboulay, Henle, Kocher, Horsley, etc.). None of these, however, present any material advantage over the original method. The operation is performed as follows:

Adhesions binding the pylorus to neighboring organs should be thoroughly freed as well as the pyloric end of the stomach and first portion of the duodenum.

The thoroughness with which the pyloric end of the stomach and the upper end of the duodenum are freed determines largely the ease and success of the operation. Much advantage is gained from this so-called mobilization of the duodenum. Kocher later emphasized the great importance of this procedure. A suture to be used as a retractor is taken in the upper wall of the pylorus, which is then retracted upward by means of this suture. A second suture is then placed in the anterior wall of the stomach and a third in the anterior wall of the duodenum at equidistant points about two inches from the suture just described in the pylorus. The second and third sutures are taken as near the opposing free borders of the stomach and duodenum as possible and mark the lower ends of the gastric and duodenal incisions respectively.

Traction is then made upward on the pyloric suture and downward in the same plane on the gastric and duodenal sutures. This keeps the stomach and duodenal walls elevated and taut and allows the placing of the subsequent sutures with greater facility than if they remained retracted and relaxed. The peritoneal surfaces of the duodenum and stomach along its greater curvature are then sutured as far posteriorly as possible. For this row the continuous silk suture is to be preferred, although catgut may be substituted.

After the posterior line of sutures has been placed and tied an anterior row of mattress sutures is taken which are not tied. These

sutures after they have been placed are drawn aside, thus exposing the line of incision.

After all the anterior stitches have been placed and retracted the incision is made in the shape of a horseshoe. The anterior and posterior lines of sutures should be placed far enough apart to give ample room for the incision to be made between them. Beginning in the gastric wall, the incision is carried upward to and through the pylorus and around into the duodenum. The two arms of the incision, gastric and duodenal, should be approximately the same length. Hemorrhage is then stopped by catgut ligature of each individual bleeding vessel. Scar tissue or active ulcers present in the gastric or duodenal anterior wall may be excised through this incision.

Those in the posterior wall we have been treating of late just as other chronic ulcers, *i. e.*, excising the overhanging edges of mucous membrane and incising the dense fibrous base, care being exercised to avoid perforation of the posterior wall of the stomach and to stop all hemorrhage by ligature or suture.

The opportunity thus afforded to explore digitally and inspect the ulcerated area and then excise it through this incision is in our judgment one of the strongest points in favor of the operation.

A continuous catgut suture is now taken through all the coats of the stomach and duodenum on the posterior side of the incision in order to reinforce this line of sutures. The anterior sutures are then straightened out and tied and the operation thus completed. The mattress sutures may be reinforced with as many Lembert sutures as may be thought best. All the stitches are thus placed and the posterior row tied before the bowel is opened and it remains open only long enough to control the hemorrhage and excise any ulcer that may be present, thus giving the minimum of exposure of possibly infected surfaces.

The size of the newly formed pylorus may be made as large or small as desired. Unless the stomach is very much dilated or has descended to an unusual extent the lower limit of the new pylorus will be found to be at or near the level of its most dependent part.

This operation has its greatest indication in the relief of benign stenosis of the pylorus, due either to spastic conditions set up by ulcers situated at or near and on either side of that orifice or cicatricial conditions following the healing of such ulcers. The relief afforded by the operation seems to be equally satisfactory whether the obstruction is of functional or organic origin.

Among the special advantages offered by this operation is that it retains to a large extent the normal anatomical relationship between the stomach and duodenum. It also affords the opportunity of excising all ulcers situated on the anterior walls of the part affected, also the opportunity to apply appropriate treatment, such as excision of edges, scarification or curettement of base, etc., to ulcers situated in the posterior walls and which cannot, therefore, be readily excised as in the anterior walls. In case of spastic contraction of the pylorus, of reflex

nervous origin caused by an irritation in the immediate neighborhood (gastric or duodenal ulcers) or from a distance (chronic appendicitis, gall-stones, etc.), the most gratifying results may be confidently expected by the division of the pyloric sphincter.

The operation is contra-indicated in all forms of so-called nervous dyspepsias not dependent upon demonstrable organic disease; and where the duodenum cannot be thoroughly mobilized owing to too dense adhesions and too pronounced thickening and infiltration about the pylorus.

Gastroduodenostomy.—Various methods of joining the duodenum to the stomach have been from time to time suggested, the idea of the operation being to afford an outlet to the stomach as near as possible to the normal one and to prevent the regurgitation of bile into the stomach by making the intestinal anastomosis above the opening of the common bile duct. These operations (Jaboulay, Kümmell, Villars, Kocher) have all fallen into disuse and are now of historic interest only, having been superseded by gastro-enterostomy and pyloroplasty. The reason for this is that they, while physiologically correct, are more difficult to perform than the latter and the results in the long run are not so satisfactory.

Gastro-enterostomy.—This is probably the most frequently performed of all operations upon the stomach. Although physiologically and mechanically unsound, in properly selected cases the results are usually quite satisfactory. There are, however, certain well-defined limits to the usefulness of the operation which should be carefully observed. There are as well certain unpleasant sequelæ to which more extended reference will be made later. The mortality rate, thanks to the perfection of our modern technic, is small, so small, in fact, as by its very insignificance to constitute somewhat of a menace in the way of a temptation to do the operation at times when the indications for it are not sufficiently clear. Particularly is this true in that class of cases in which the pathological findings at operation do not correspond with the clinical history of severe gastric distress. Under such circumstances and without adequate pathological evidence of disease, especially of obstruction at the pylorus, the operation of gastro-enterostomy has not infrequently been done, especially by inexperienced operators, with the natural sequence of a large percentage of unsatisfactory results. It is this fact unquestionably which has helped to place the operation in undeserved disrepute. When performed with proper indications it is a good operation and followed not infrequently by the most brilliant results. But it should not be forgotten that it is capable of doing a great deal of harm in unsuitable cases and when carelessly performed. The chief indications for the operation are obstruction at the pylorus from any cause and ulceration of the stomach or duodenum. It is performed at times under other conditions, such as hemorrhage, perforation, certain forms of gastric dilatation (gastromesenteric ileus), after resections of the stomach wall, etc. It will be found to be an invariable rule that the more pronounced the pathological process

present at the time of operation the more satisfactory will be the subsequent result, although in cancer, of course, it is only temporary.

The contra-indications to the operation are the absence of an easily demonstrable pathological lesion of the stomach or duodenum and in all functional and nervous disturbances of the digestive tract.

The preliminary preparation of the patient is that for gastrotomy, and, where possible, should be thoroughly and conscientiously carried out. The operation of choice is always the so-called "posterior-no-loop" method. The other methods of performing the operation are invariably operations of necessity, although even under such circumstances they not infrequently yield satisfactory results. The percent-

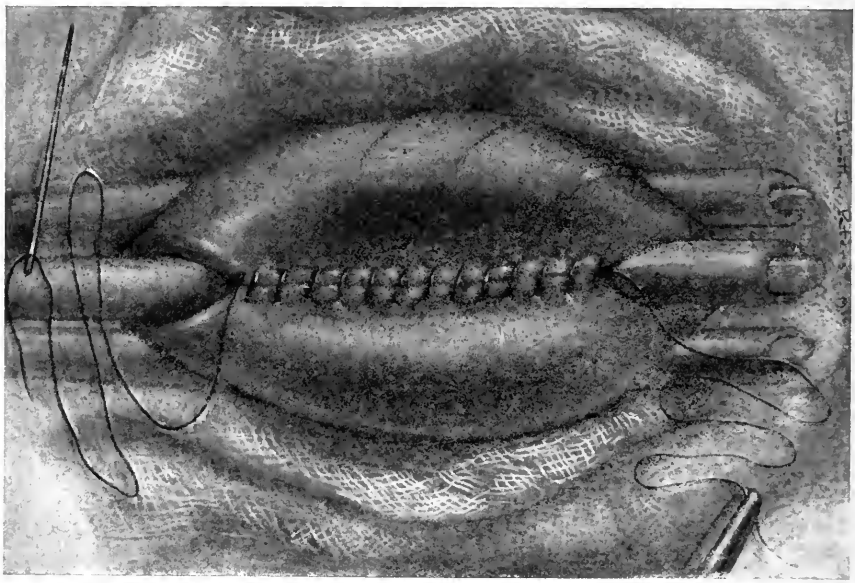


FIG. 294.—Gastrojejunostomy made with three sutures on posterior line because of occasional hemorrhage into the gastro-intestinal tract after clamps are removed. Drawing shows posterior line of musculoperitoneal sutures in place. (William J. Mayo.)

age of good results, however, is generally higher with the posterior-no-loop method, and hence it should be given the preference when possible.

The right rectus incision will be found to give just as good exposure when extended sufficiently as any other, and is less complicated, hence it is to be preferred. Plenty of room and good exposure of the structures to be examined ensures gentler handling of tissues than pulling and rough handling through a too small opening. A long incision heals just as quickly and just as soundly as a short one, when properly sutured.

Anterior Gastro-enterostomy.—Through a right rectus incision, find and identify the stomach and upper end of the jejunum. The former is easy to recognize. The latter can always be found by first locating the duodenojejunal angle by making taut the transverse

mesocolon on lifting up the transverse colon. The jejunum, when normally placed, will be seen to be attached to the under surface of the mesocolon where it comes through. The fold of peritoneum known as the ligament of Treitz, attaching its upper surface to the under surface of the mesocolon, serves as an additional source of identification. If the top loop of the jejunum does not readily present itself, sweep the hand along the under surface of the root of the taut mesocolon to the left of the patient's spine, as suggested by Moynihan, and the loop will be found. Its identification should always be made sure as above before proceeding with the succeeding steps of the operation. The spot which is generally selected for the site of the anastomosis is on the anterior stomach wall as close as possible to the greater curvature

FIG. 295.—Gastrojejunostomy made with three sutures on posterior line because of occasional hemorrhage into the gastro-intestinal tract after clamps are removed. Drawing shows catgut buttonhole suture applied posteriorly without opening mucous membrane. (William J. Mayo.)

at its lowest point. This portion of stomach wall, together with the loop of jejunum, is then carefully drawn through the abdominal incision and the peritoneal cavity gently yet thoroughly walled off with sterile gauze pads, wet with normal salt solution. A point in the jejunum should be selected as the site of the anastomosis just far enough removed from the duodenojejunal angle to prevent either traction on the line of suture or too great redundance of bowel wall. There are many methods of making a junction between the two, but the same method should be employed as that described under posterior gastroenterostomy. After removing the gauze packing and cleansing and inspecting the field of operation and reinforcing the line of suture with here and there a Lembert stitch, as needed, close the abdomen in the usual fashion.

Posterior Gastro-enterostomy.—Since this operation was first described by von Hacker it has gone through many modifications, and

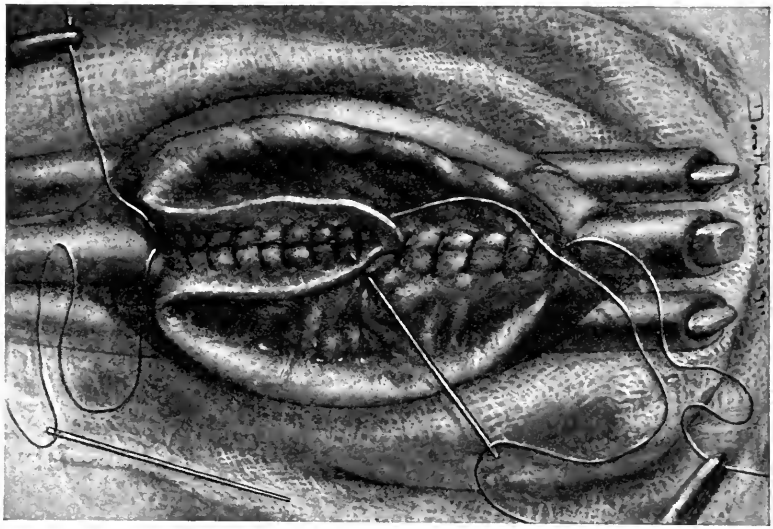


FIG. 296.—Gastrojejunostomy made with three sutures on posterior line because of occasional hemorrhage into the gastro-intestinal tract after clamps are removed. Drawing shows mucous membrane opened. Running suture of catgut to bring mucous coats of stomach and jejunum together. (William J. Mayo.)

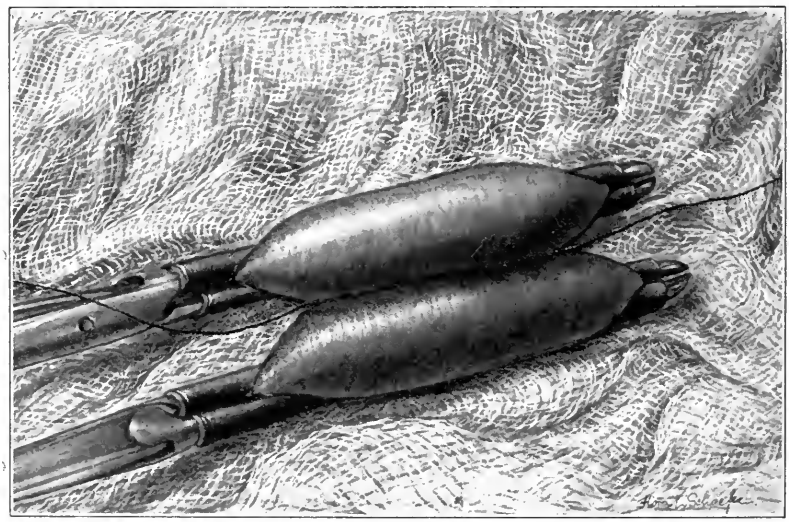


FIG. 297.—Showing posterior continuous suture of fine black silk uniting stomach and intestines, after clamps protecting gauze have been placed in position.

while the essentials have remained the same, as performed in the best clinics today, it has been in certain important particulars changed and

improved. The operation that is in most general use in this country, at least, is essentially that which is used in the Mayo clinic, and may be described as follows:

Through a right rectus incision of sufficient length to allow of easy access to the whole of the upper abdomen, expose and examine thoroughly the stomach, duodenum and surrounding structures in order that no anatomical anomaly or pathological condition may be overlooked. Note the approximate point on the stomach where it is desired to make the anastomosis, separating any adhesions to surrounding structures in order to mobilize freely the parts affected by the operation

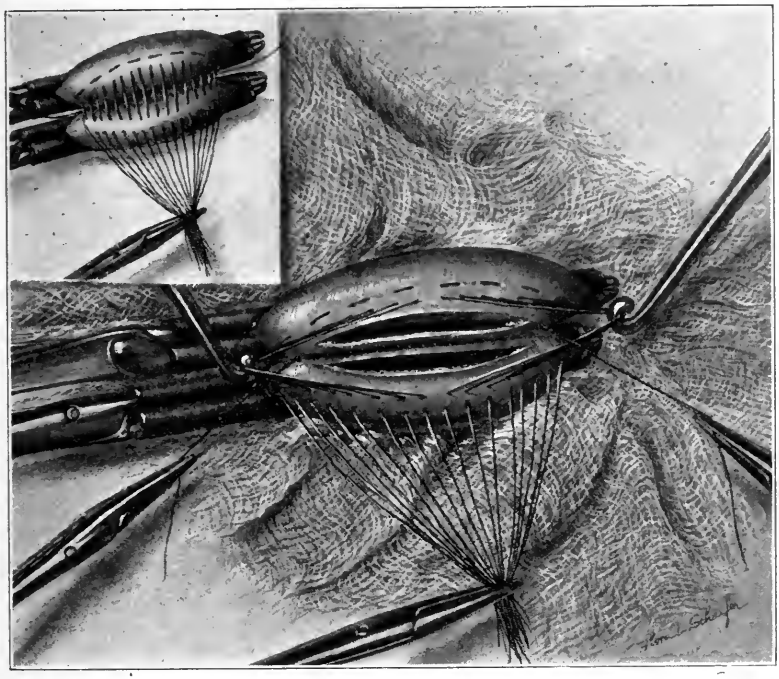


FIG. 298.—Showing anterior mattress sutures drawn aside and incision for new stoma made through stomach and duodenal walls. Small figure showing anterior mattress sutures in place.

Lift the transverse colon and its attached great omentum out of the abdomen and turn them up over the costal border so as to expose the under surface of the transverse mesocolon and the upper portion of the jejunum where it comes through. If the transverse colon is held up so that the light can shine through its mesocolon one can see the network of mesenteric vessels with their arches and thus be able to avoid them. Select an area as free as possible from bloodvessels and tear through it with a blunt instrument or the finger. A good guide to this spot is the line of attachment of the ligament of Treitz. The posterior wall of the

stomach should then be pushed through the rent just made and held there by intestinal forceps, or, better still, by two intestinal stitches passed through the stomach wall, about three inches apart, and used as retractors. They do less damage to the gastric wall than any forceps, and are more satisfactory. A fold of the protruded posterior wall of the stomach is then taken up and held in an intestinal clamp selected for the purpose. The kind of clamp used depends upon the choice of the individual surgeon, whether two clamps, straight or curved, or the double Roosevelt clamp, is immaterial. Most surgeons prefer to have the blades of the clamp covered with rubber tubing. In applying the clamp to the stomach wall it should include the lowest portion of the greater curvature and, if possible, an inch or so of the anterior wall

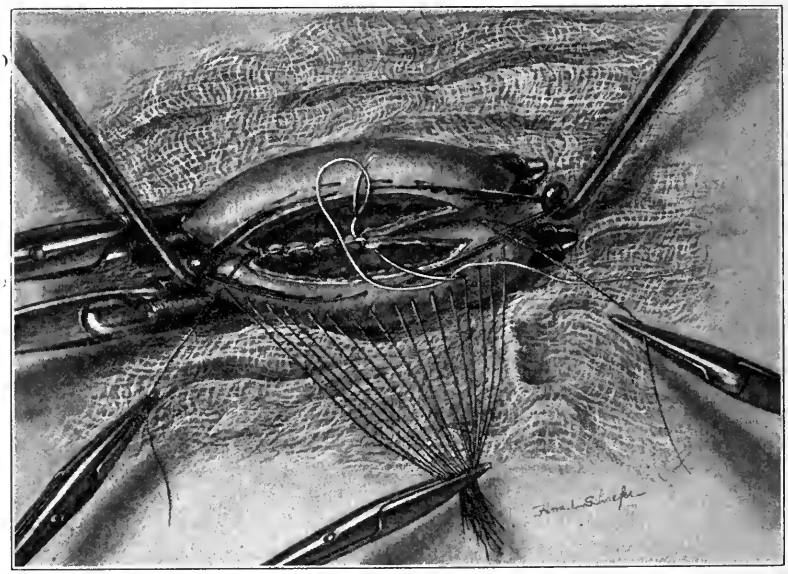


FIG. 299.—Showing through-and-through continuous buttonhole catgut suture through the posterior walls. This suture serves the double purpose of controlling hemorrhage and securing better apposition of the walls.

which can usually be pulled through the opening in the mesocolon, especially if the gastrocolic omentum with the gastro-epiploic artery is separated somewhat from the greater curvature of the stomach. The direction of the clamp should be from above downward and from right to left. Similarly the clamp should be applied to the jejunum in its long axis. It should be applied to the bowel just as high up as it can be conveniently done, usually within two or three inches of the duodenojejunal junction. The two clamps should then be laid side by side and a strip of gauze placed beneath them and immediately behind the projected line of anastomosis. Then carefully and thoroughly pack off the rest of the peritoneal cavity and protect the edges of the abdominal

incision with gauze pads moistened with warm normal salt solution. "Unite the stomach to the jejunum for a distance of about two and a half inches by a row of mattress sutures exactly as in intestinal lateral anastomosis (posterior serous suture). Make an incision parallel to and shorter than the posterior serous suture through all the coats of the stomach except the mucosa. The mucosa now pouts up into the wound. Make a corresponding incision in the jejunum. Introduce a buttonhole or locking continuous suture of chromicized or formalinized catgut, including in each stitch (*a*) a bit of the unopened gastric mucosa, (*b*) the other coats of the stomach, (*c*) the serous and muscular coats of the jejunum, (*d*) a bit of the unopened jejunal mucosa. This line of suture unites the posterior edges of the stomach wound to the corresponding wound in the jejunum. Incise the mucosa of the stomach and jejunum and with the same needle and catgut suture used in the

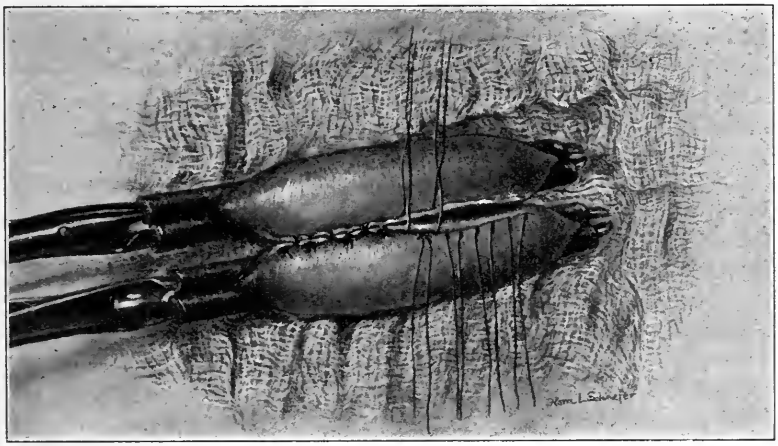


FIG. 300.—Showing mattress sutures tied after hemorrhage along anterior walls has been stopped by ligation of individual vessels. Also Lembert sutures placed between adjacent mattress sutures completing the operation.

preceding line of suture unite by a whip stitch the mucous coats of the stomach and jejunum. With the same suture unite the anterior edges of the stomach and intestinal wounds by means of a Connel stitch (through all the coats of the organs), or of a through-and-through buttonhole (or locking stitch) exactly as in the lateral anastomosis. Remove the intestinal clamps, complete the serous suture, as in lateral anastomosis" (Binnie). Cleanse the field of operation with gauze sponges wet with warm normal salt solution, remove all the gauze packs and inspect carefully the entire line of sutures, front and back, and insert here and there, as needed, Lembert sutures of fine silk. Then attach the edges of the rent previously made in the mesocolon to the stomach or duodenum a little way from the suture line and in such a way that the raw edges will be inverted. This step may be taken

before instead of after the anastomosis. Care should be taken to avoid puncture of the walls of mesenteric veins with these sutures otherwise a troublesome hematoma may develop. Replace the stomach and intestine as nearly as possible in their normal position. Close the abdomen in the usual manner without drainage.

This method as just described is modified in slight particulars by different surgeons, *i. e.*, some surgeons still use a continuous suture throughout the anastomosis. Mayo found that this continuous suture when of silk or linen gave rise, in a considerable number of cases, to later trouble by partially sloughing through into the lumen of the stomach while still remaining attached to the margin of the stoma, and thus causing irritation and secondary ulceration. For this reason the use of silk has been recently abandoned altogether in the Mayo clinic in gastric surgery. It is well always to make the anastomosis sufficiently large, say two inches in length and to bear in mind Moynihan's injunction, to excise thoroughly the free edges of the gastric and intestinal mucosa to prevent subsequent cicatricial stenosis. The operation can be very well performed without the aid of gastro-intestinal clamps, indeed some surgeons prefer this way of doing it. There are objections to either method, but they can usually be overcome by care and attention to details, such as control of hemorrhage, prevention of soiling of peritoneal cavity with stomach and intestinal contents, etc.

Many different methods of posterior gastro-enterostomy have been described from time to time; none of them are in very general use, however, except the one just described, hence they will not be described in detail but only the salient and distinguishing features in which they differ from it.

Roux's Operation.—The "operation en Y," as it is sometimes called, differs in this respect, that instead of anastomosing the duodenum to the posterior wall of the stomach a loop of jejunum a few inches from the duodenojejunal juncture is lifted up and divided straight across between two intestinal clamps. The cut end of the lower segment is anastomosed directly into the stomach at the usual gastro-enterostomy point of election, next anastomose the lower end of the upper fragment into the side of the jejunum a few inches below the point of its junction to the stomach. The special idea of this operation is to prevent the formation of the "vicious circle."

Instead of this procedure of Roux, but in very similar fashion, some surgeons hope to accomplish the same result by anastomosing the afferent to the efferent loop a few inches below the gastro-enterostomy opening.

Mikulicz and Czerny call attention to the fact that, owing to the anatomical relationship existing between the posterior wall of the stomach and the upper three or four inches of the jejunum, an anastomosis can be made at this point by a transverse incision in the jejunum and one close to the greater curvature of the stomach which

will drain it at its lowest point, and will, at the same time, prevent the possibility of kinking of the intestine. Petersen emphasizes the necessity of making the anastomosis as close as possible to the origin of the jejunum in order to prevent obstruction. The results, with this method, have not fulfilled expectations, and hence it has fallen into disuse.

The Magraw elastic ligature and the method of Maury which substitutes heavy twine string for the rubber tubing and places the stitches in a triangular fashion on either side are both open to the serious objection that they rely upon the sloughing through of the tissues included in the ligature and that the opening up of the new stoma is delayed, a serious drawback in case of a debilitated patient.

The method of performing posterior gastro-enterostomy invariably used by the writer is practically that of the intestinal suture first suggested by Halsted, with some slight modification. The steps of the operation are the same as the ordinary posterior operation as far as the placing of the clamps, then the gastric and intestinal loops are sutured together just as in the writer's pyloroplasty method by a continuous fine silk suture, which should include the submucous coat of the intestine. This suture should be placed as far posteriorly as possible in order to give plenty of room for the anastomotic opening between it and the line of anterior sutures. These latter should consist of mattress sutures, which should be placed far enough forward of the posterior line, say not less than one-half an inch, in order to allow of sufficient space between the two suture lines for the incision. All the mattress sutures are placed and the loops drawn aside and then parallel incisions of equal length made through the walls of the stomach and jejunum. Next apply a continuous buttonhole catgut suture (through all the coats of the stomach and intestine) to the posterior edges of the incision through their walls. Loosen the gastro-intestinal clamps. Tie off with catgut every bleeding-point. Not infrequently it will be found necessary to ligate vessels in the posterior walls, which are to be seen bleeding through and in spite of the continuous buttonhole catgut suture and uncontrolled by it. It is this fact that the writer has so often observed that has convinced him that reliance cannot be placed in the continuous suture for the absolute control of hemorrhage, and which has caused him to abandon the use of the continuous suture in the anterior walls and to adhere to this method of anastomosis. Pull taut and tie the mattress sutures previously placed. It will be observed that when interrupted mattress sutures are used the raw edges of the wounds in the intestinal walls always spontaneously invert when they are tied. A Lembert suture is placed between adjoining mattress sutures for additional security. No suture is placed in the mucosa of the anterior walls. Experience has shown it to be unnecessary. The entire suture line is then carefully inspected and an additional suture placed here and there, as may seem to be needed. The operation is then completed in the usual fashion.

Pyloric Exclusion.—There still remain sharp differences of opinion among surgeons as to the advisability of excluding the pylorus after gastro-enterostomy. The weight of surgical authority, however, would seem rather to incline against it, as adding to the risks of the operation and further complicating it without correspondingly increasing its effectiveness. The advocates of the procedure recommend it in practically all cases as obviating most, if not all of the unpleasant sequelæ that have been from time to time observed. Since von Eiselsberg first recommended the operation, various modifications have been brought forward. All sorts of materials have been used to bring about the occlusion.

The idea of the operation is to block the passage of food from the stomach into the duodenum after gastro-enterostomy, thus forcing it to escape through the new stoma. The occlusion should take place proximal to the ulcer. There are several types of operation described. Complete division of the duodenum, pylorus or pyloric antrum, as the case may be, has been advised and practised by some, with differing methods. (von Eiselsberg, Doyen, Bartlett.) The duodenum, or better the stomach, is divided between two clamps which have been applied proximal to the ulcer and through openings that are made for the purpose in the lesser and gastrocolic omenta respectively. The cut ends are then closed with two rows of sutures.

Recently a number of cases have been reported following this operation of the formation of a pouch from the closed pyloric end of the stomach, necessitating some operative procedure, *e. g.*, the shortening of the hepatic ligament to prevent further sagging and dilatation. Simple ligation of the pylorus, either with or without the reflection of cuffs of the serous and muscular coats, has many advocates. Foreign materials, such as silk, catgut tape, metallic bands, etc., or strips of fascia from the rectus or fascia lata, the round ligament of the liver and strands of omentum, have all been recommended from time to time as materials with which to occlude the pylorus. Successful cases have been reported after the use of each one of them. It is probable that the occlusion of the pylorus renders somewhat more sure the success of the gastro-enterostomy and makes less likely the development of the "vicious circle." Other things being equal, however, it should not be performed as a routine but only in cases of hemorrhage or impending perforation of duodenal ulcer. The best of the methods as suggested at the present time are probably those that use a band of omentum or other fresh connective tissue as the occluding material. In many of the cases in which ligation without division of the pylorus has been used the lumen of the bowel has been observed later to become reëstablished to a certain extent. This does not seem to constitute a serious objection, since the "vicious circle" is an early rather than a late complication of gastro-enterostomy.

Vicious Circle.—This is a very serious and intractable complication of gastro-enterostomy. Fortunately, owing to the perfection of present-

day methods, this grave sequel is observed far less commonly than formerly. It is caused by the passage of food from the stomach into the afferent instead of the efferent loop of bowel. It is usually due to faulty technic, the junction of the bowel to the stomach at a wrong angle or in a wrong place giving rise to obstruction of the efferent loop from angulation or pressure or rotation upon its long axis, making a valve formation. The no-loop operation when properly done is particularly free from this complication, and hence should always be given the preference when possible. The only really effectual means of preventing its occurrence are primarily unfailing care and attention to every detail of the operation and the joining together of the afferent and efferent loops of jejunum by a lateral anastomosis between the two, followed by complete division of the afferent loop and closure of the cut ends by suture. Roux's "Y" operation is also used for this purpose, but it is not so satisfactory. Occasionally one observes a case presenting all the symptoms of "vicious circle" recover under lavage and change of position, but, as a rule, when once well established, prompt secondary operation is indicated.

Peptic Ulcer.—One of the unpleasant sequelæ that have been observed to follow gastro-enterostomy is the development of secondary ulcer or ulcers. They occur most often in the segment of the jejunum proximal to the anastomosis. They follow with far greater frequency the anterior than the posterior no-loop method, and usually just at or in the immediate neighborhood of the anastomotic opening. Fatal cases of perforation and hemorrhage have been observed. Although it is a comparatively infrequent complication it is always serious, and its presence should always be suspected in those cases where pain and other symptoms develop subsequent to gastro-enterostomy. It is probable that faulty technic, especially the employment of continuous non-absorbable sutures, may give rise to the condition in a considerable number of cases. When its presence has been diagnosed, operation is always indicated as the only effective form of treatment. The operative procedure to be carried out depends largely upon the nature of the pathological process found present. The most radical method of dealing with the situation, other things being equal, probably yields the best results, namely, excision of the old anastomotic area, stomach and jejunum, including all ulcerated areas, closing the openings in both and restoring the continuity of the bowel by end-to-end or lateral anastomosis, as may seem best, in the individual case. When the continuity of the bowel cannot be readily restored, or when, for any other reason, it may be inadvisable, the posterior anastomosis may be performed at a new site or a simple anterior gastro-enterostomy may be the best that one can do with safety. Rarely it may be found possible simply to excise the ulcer without disturbing the anastomosis.

Intestinal Obstruction Following Gastro-enterostomy.—One of the rarer complications observed as a result of gastro-enterostomy, particularly the posterior-no-loop method, is the obstruction produced by a coil of

intestine slipping into the foramen formed by the afferent loop of the jejunum which is attached both at the duodenojejunal junction and at the stoma. When subsequent to a gastro-enterostomy operation symptoms of persistent intestinal obstruction develop, this possibility should be borne in mind. In order to prevent its occurrence, the foramen should be obliterated by suture of the afferent loop to the under surface of the transverse mesocolon. If the condition is recognized early enough the engaged loop of bowel can be readily released. When the operation has been too long delayed it may be necessary to resect the injured segment as in other cases of intestinal obstruction.

SURGERY OF THE DUODENUM.

By ALBERT J. OCHSNER, M. D., LL.D., F.A.C.S.

Embryologically the duodenum is a part of the stomach, as it develops from the foregut and maintains physiologically and functionally its position as a part of the stomach by continuing the process, initiated in the stomach, of preparing the food for absorption in its passage through the alimentary canal.

The stomach acts as a reservoir, a retort, a mixing and a grinding apparatus. The duodenum continues the mixing process after adding the alkaline secretions of the liver and pancreas.

DUODENAL ULCER.

The most common surgical disease of the duodenum corresponds to the same condition in the stomach in the form of ulcer.

The diagnosis of this condition has been fully discussed in a previous chapter.

Symptoms.—Regarding the history of duodenal ulcer, what is known as "hunger pain" is the most important factor.

While in gastric ulcer the pain appears soon after the ingestion of food, in duodenal ulcer it rarely appears earlier than two hours after taking food, and more commonly later than four hours. In many cases severe pain appears six to seven hours after dinner, the interval between breakfast and luncheon, and between luncheon and dinner being too short for pain to appear. Many of these patients regularly awaken between 1 and 4 A.M. with severe pain, which subsides upon taking food or bicarbonate of soda. The physical examination results in pain upon pressure from 2 to 4 cm. to the right and a little above the umbilicus.

In case of referred pain in the back, which occurs when the ulcer is situated on the posterior surface of the duodenum, the pain is likely to be located to the right of the midline often as high as the angle of the scapula, but it may be located so low as to be confounded with the pain which is commonly encountered in gall-stone disease.

Vomiting may occur, but this is not so common as in gastric ulcer; and vomiting of blood is extremely uncommon, although this may occur.

Mayo has established the fact that duodenal ulcer is about three times as common as gastric ulcer, a fact which had been overlooked by earlier observers, probably because these ulcers were formerly classified with gastric ulcers, because most of them are located with their margin in the duodenum directly outside of the pylorus.

A history of a recent cutaneous burn accompanying the symptoms of ulcer speaks for duodenal and against gastric ulcer.

This condition can usually be confirmed by making a fluoroscopical examination, the patient having been given a quantity of gruel or

buttermilk in which barium sulphate or bismuth subcarbonate has been suspended.

It seems wise to caution the surgeon against making a diagnosis upon the evidence contained in *x*-ray plates, because these may be entirely misleading, and consequently such a diagnosis would be dangerous to the patient because it frequently results in unnecessary operation. On the other hand, if a positive diagnosis has been made upon evidence obtained from a carefully taken history, and a physical examination by the experienced surgeon himself, then it may be perfectly proper to confirm this diagnosis by the reading of *x*-ray plates, because in this case the procedure is, of course, entirely harmless and it may give both the roentgenologist and the patient a high degree of satisfaction which may have a certain amount of value. In any case the *x*-ray examination should always follow the taking of a concise history and a painstaking physical examination. In almost every instance it is possible then to confirm the diagnosis, especially by means of the fluoroscopical examination.

By following this system one can avoid errors which are otherwise sure to occur because of clouding or confusing the diagnosis directly as a result of conclusions drawn from the *x*-ray appearance. It is for this reason that diagnosticians should invariably be present at the operation so that they may see the diagnosis confirmed or discredited, and for the same reason the surgeon should invariably make his own independent diagnosis.

Treatment.—The surgical treatment of duodenal ulcer must be carried out on the exact lines described in the treatment of gastric ulcer in a previous chapter with the exception that pyloroplasty can be employed only in very rare cases, and that excision of the ulcer is only very rarely possible.

In case the use of non-irritating liquid or semi-liquid food to which an alkaline substance such as milk of magnesia, magnesia carbonate, lime water or bismuth subcarbonate has been added, does not permanently relieve a patient suffering from duodenal ulcer, surgical interference is definitely indicated.

It is, however, important that this form of non-surgical treatment be given a fair trial, that it be carried out with regularity and that the patient actually keep alkaline food in his stomach practically all day and all night. If he receives alkalinized non-irritating food like milk, gruel or soup, to which one of the above remedies has been added, every two or three hours during the daytime, say for twelve hours, and then exposes his ulcer to the acid gastric juice during the remaining twelve hours out of the twenty-four the effect will be satisfactory only in a very small proportion of cases.

In other cases in which the treatment has been carried out systematically night and day until all of the pain has disappeared, if the patient at once resumes his careless habits of eating, there is almost certain to be a recurrence, while the same patient might be readily expected to obtain a permanent cure in case he had continued the treatment for several months, and had later abstained from eating

articles of food of the kind that had presumably given rise to the original ulcer.

We have had under our observation a very large number of patients who have remained free from recurrence of gastric and duodenal ulcer for many years by strictly adhering to a diet list, of which the following is a sample with modifications suited to the individual case.

Read this diet list once a week and follow absolutely.

Take 1 pint of hot milk with 2 to 4 teaspoonfuls of milk of magnesia at 6, 9, 12, 3, 6, 9 and 1, or take ½ pint hot milk with 1 to 2 teaspoonfuls of milk of magnesia at 2, 6, 8, 10, 12, 2, 4, 6, 8 and 10.

Later you may take the other articles of food in addition at 12 M. and at 6 P.M.

When you come to eat solids, chew them a very long time to mix with saliva.

1st Week.—Take 4 to 6 pints of hot milk daily with medicine; if this is not sufficient to keep up your strength, you may add from 1 to 4 raw eggs.

2d Week.—Take same as 1st, and 2 to 4 raw or soft-boiled eggs in addition.

3d Week.—Take same as 2d, and 2 to 6 pieces of very dry toast in addition, which must be chewed very fine.

4th Week.—Take same as 3d, and all kinds of milk or cream soup in addition.

5th Week.—Take same as 4th, and all kinds of mush or boiled rice in addition.

6th Week.—Take same as 5th, and broiled, stewed or boiled beef or mutton in addition; chew and swallow the juice but not the fiber.

Later you may swallow the beef or mutton, but not until you have been free from pain for at least three months.

Even after recovering fully, do not eat pastry, pie, pancakes, pickles, pork or puddings. No cake, candy, or canned goods. No raw vegetables or raw fruits, unless the latter are perfectly ripe and not sour.

In case the milk of magnesia acts too freely on the bowels, use 4 tablespoonfuls of lime water for each pint of hot milk instead.

Use the above diet for at least six weeks and go back to it at any time when your stomach may be giving trouble.

Use the Following Diet After Six Weeks.

You should drink as nearly as possible 2 quarts of rich milk, preferably hot, each day, always adding from 2 to 4 teaspoonfuls of milk of magnesia, or 4 tablespoonfuls of lime water to each pint of milk.

You should eat from 2 to 6 raw or soft-boiled or poached eggs a day.

Aside from this, you should eat broiled, stewed or boiled beef, mutton or fresh fish, cooked vegetables or cooked fruits and all kinds of thoroughly cooked mush and breakfast foods, also very ripe non-acid fruits. You may chew the meat and swallow the juice but not the pulp.

You should eat no candy, sugar or vinegar; no pastry, pie, pickles, pancakes, pork or spiced foods, and no unripe or acid fruits, no vegetables that have not been thoroughly cooked or contain hard fibers.

You should chew all food for a long time in order to mix it thoroughly with saliva.

You should drink neither tea nor coffee, nor anything containing alcohol.

You may drink hot water with cream, or hot milk with fresh cream, or buttermilk with fresh cream with your meals or half way between meals or at bed time.

You should rest at least fifteen minutes before dinner and supper.

You should sleep with wide open windows, and go to bed early.

In the first case the patients take 1 pint of alkalinized milk, which may be varied with gruel or puree every three hours, with four and five hours' intervals at night; in the second case $\frac{1}{2}$ pint with two hours' interval during the day and four hours at night.

This plan of treatment is so simple that it can easily be followed by any patient of reasonable intelligence, and it does not expose the patient to unnecessary hardship.

The same plan is followed after recovery from operation for the cure of duodenal or gastric ulcer.

The patient is instructed to adhere to part one of this diet so long as he suffers from any digestive disturbance, and then to change gradually to part two. In case of any return of trouble the patient immediately returns to part one and continues with this until entirely relieved, and then he changes gradually to part two and continues with this diet so long as he is free from gastric or duodenal disturbance.

The surgery of the duodenum is confined almost exclusively, aside from the treatment of duodenal ulcer, to carcinoma of the common bile duct, implicating the papilla which may necessitate the excision of this portion of the duodenum, but this condition is usually so far advanced when diagnosed that one rarely encounters an operable case.

The following operation has been suggested, and in case one should meet a circumscribed carcinoma early enough to justify any operation, it seems worth while to bear this method in mind.

The tumor should be approached from the side of the mucous membrane of the duodenum in order to obtain a complete removal, together with a sufficient amount of the surrounding mucous membrane. The same preliminary preparation is employed that has been described in connection with operations upon the stomach, especial care being taken to make careful gastric lavage and leaving the tube in the stomach in order to siphon out all fluid.

Operation.—*Incision.*—A median incision extending from the end of the sternum to a point 3 cm. below the umbilicus provides an excellent approach to all operations upon the duodenum. The anterior wall of the intestine is caught at two points, 5 cm. and 10 cm. from the pylorus and well to the left of the middle of the anterior surface. The lumen of the intestine is then opened by means of a longitudinal incision extending from one to the other of these points.

The edges of this incision are then caught with four to six fine mouse-tooth forceps, of the Allis type, care being taken to catch all layers—mucosa, muscularis and serosa—in order that these may not be separated during the subsequent manipulations.

The tumor, together with the surrounding tissues for a distance of 2 cm. beyond the margin of the growth, is then separated by means of the electric or Paquelin cautery, leaving an opening in the duodenum at the point of entrance of the common duct.

This opening is then closed by placing a transverse row of interrupted Connell sutures of fine silk from within the lumen of the intestine. In this manner there will be no narrowing of the duodenum at this point. A few interrupted Lembert sutures may be added from the outside to increase the security of the Connell sutures.

This operation is indicated only in very circumscribed tumors, and in this stage the involvement of the common duct will be limited sufficiently to leave enough uninvolved duct so that this can be implanted into the side of the duodenum at a point necessitating little or no tension.

This can be accomplished readily so long as the original incision in the intestine has not been closed.

Virtually the identical operation which has been described for the implantation of the ureter in the side of the bladder can be employed.

A small puncture is made in the wall of the intestine. The common duct which has been freed while it was still attached to the tumor is drawn through the punctured wound for a distance of 0.5 cm. and the mucous membrane of the duodenum is sutured to the outside of the duct by means of four to six fine silk sutures on fine curved needles.

The serous surface of the intestine is then sutured in the same manner to the outside of the duct, at least two rows of fine interrupted silk sutures being employed in order to prevent leakage.

A small piece of omentum is then sutured over the suture line for further security.

In case it is not possible to utilize the remaining portion of the common duct after removing the tumor, this should be securely ligated by the use of chromic catgut or strong fine silk, two distinct ligatures being employed, then the stump should be covered with peritoneum.

In order to secure drainage for the bile, it now becomes necessary to make use of the gall-bladder by performing cholecystenterostomy described in another chapter.

This operation can also be performed most conveniently before the original wound in the duodenum has been closed. The point at which the gall-bladder is to be implanted in the side of the duodenum should be selected so as to reduce tension to a minimum. In this class of cases the obstruction to the common duct, caused by the presence of the tumor, has usually caused a dilatation of the common duct and the gall-bladder so that this part of the operation can be readily accomplished.

Embryologically, as stated before, the duodenum is a part of the foregut in common with the stomach; it should consequently be treated as part of the stomach.

There is, however, this one distinction: that ulcers are more common in the duodenum than in the stomach, while carcinoma is of exceedingly rare occurrence in the duodenum, whereas it is most common in the stomach.

So long as we are in ignorance of the cause of carcinoma, it would seem scarcely worth while to mention any theories in explanation of the marked difference in frequency of carcinoma on the stomach and on the duodenal sides of the pylorus. There are, however, these marked differences:

1. The gastric fluid has an acid reaction while the contents of the duodenum are rendered alkaline by the bile and pancreatic fluid. Cancer is supposed not to thrive except in acid media.

2. The pyloric end of the stomach is exposed to trauma because it is in this part of the stomach that the food is ground.

3. The mucous membrane of the stomach is exposed to irritation due to the ingestion of hot food, while the mucous membrane of the duodenum is free from this source of irritation.

4. Unclean food remains in contact with the mucous membrane of the stomach for a considerable period of time, while it passes rapidly over the mucous membrane of the duodenum.

Because carcinoma develops so rarely upon the base of duodenal ulcers, it becomes necessary only very rarely to excise a duodenal ulcer. This is a fortunate circumstance, because these ulcers are very commonly adherent to the pancreas.

It may happen that a duodenal ulcer threatens to perforate even after gastro-enterostomy has been performed in cases in which the ulcer is located upon the anterior surface of the duodenum. In these cases the ulcer may be covered by uniting the exposed surface of the duodenum beyond the ulcer to the anterior surface of the stomach by one or two rows of interrupted Lembert sutures, or the ulcer may be excised and the wound treated according to the method described in the treatment of gastric ulcer with excision. In either case healing will take place if the passage of the acid contents of the stomach over the mucous membrane of the duodenum is inhibited by the use of a gastro-enterostomy according to the method described in a previous chapter, because this prevents the accumulation of large quantities of acid gastric contents in the stomach, and consequently this irritating fluid will no longer be forced against the ulcerated surface immediately outside of the pylorus. In performing gastro-enterostomy for the relief of duodenal ulcer, it seems wise to choose the lowest point upon the greater curvature of the stomach and at the same time approach as near as possible to the pyloric end of the stomach, because, as has been shown by the experiments of Hartman, this will ensure the passage of food through the gastro-enterostomy opening, while a greater or less amount of food will continue to pass through the pylorus if the opening in the stomach is made near the cardiac end of the stomach.

Although the presence of a gastro-enterostomy will in any case reduce the accumulation of irritating acid material in the stomach and consequently relieve, in a measure, the harmful effect upon the duo-

denal ulcer, still the benefit will be vastly increased if the opening is so placed that practically all of the contents of the stomach will pass directly from the stomach into the jejunum.

At this point it may be worth while to direct attention to an error which has crept into the surgical literature, which has served in a measure to discredit the operation of gastro-enterostomy, at least from a theoretical standpoint.

Since the introduction of the fluoroscope and the barium and bismuth meal it has been possible to follow the course of food taken from the time it enters the stomach to the time it passes through the intestine.

It has been shown by Canon and Blake that in gastro-enterostomized cats the stomach contents will continue to pass through the pylorus notwithstanding the presence of a gastro-enterostomy opening. By feeding a shot, suspended from a thread, Draper showed that it is possible for the shot to be carried through the pylorus into the duodenum and then back through the gastro-enterostomy opening into the stomach, and then again through the pylorus into the duodenum, etc., repeating this course so long as the thread would slide over the surface without being caught in some way.

These experiments seemed to show that not only did the gastro-enterostomy fail to do what was expected of it—namely, prevent the passage of stomach contents over the ulcer in the duodenum, but it also prevented the passage of the food into the distal end of the jejunum in part and tended to establish a vicious circle.

Many years ago Mayo demonstrated the fact that by making the opening in the stomach actually and not apparently at the lowest point in the greater curvature of the stomach, the occurrence of vicious circle could be eliminated in practically all cases. We have demonstrated the correctness of this view in hundreds of gastro-enterostomies which we have performed in our clinic, and by adding this feature to the one mentioned above of placing the opening at the same time as near as possible to the pyloric end of the stomach, the results have been very satisfactory. We have made fluoroscopical examinations in a large number of these cases and have found that the gastro-enterostomy openings have functionated perfectly.

The reason why there exists this difference between the experiments of Cannon and Blake and our experience in patients who have been gastro-enterostomized for the relief of gastric ulcer can be readily explained by studying the accompanying diagram (Fig. 301) which shows that the obstruction in the duodenum has resulted in a marked dilatation of the stomach, with the formation of a veritable pouch in the greater curvature of the pyloric end of the stomach. This is true only in cases in which the ulcer has existed for a considerable period of time, but as this is the only class of cases of duodenal ulcer which requires surgical treatment, it is of no importance what would happen if a gastro-enterostomy were performed in a healthy unobstructed stomach. It seems clear that in the presence of this dilatation it cannot be possible for the muscles of the stomach wall to contract in a

manner which will carry contents past an opening at the point "*a*" and through an obstruction in the duodenum. In case the stomach wall regains a sufficient amount of tone to contract sufficiently so that the greater curvature of the stomach will attain approximately a normal position, it is conceivable that in the meantime the duodenal ulcer might have healed, eliminating the obstruction to a great extent. In this case it is possible for a portion of the food to pass through the pylorus and a portion through the gastro-enterostomy opening, but this is, of course, of no importance so far as the clinical result is concerned.

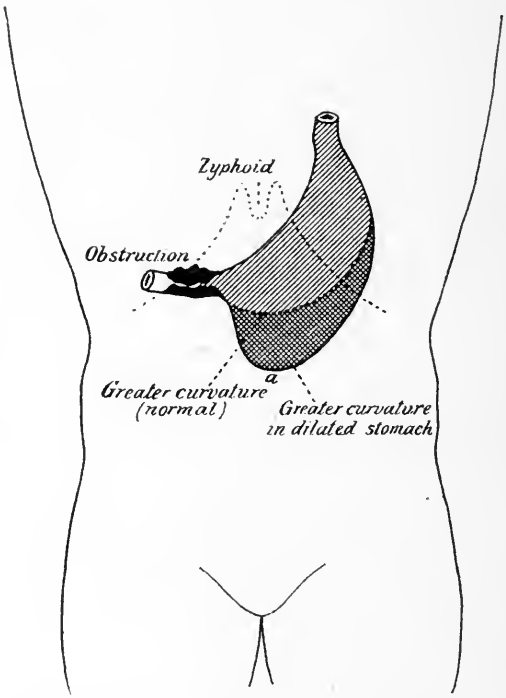


FIG. 301.—Diagram representing position of greater curvature of normal stomach and of stomach dilated because of obstruction due to indurated duodenal ulcer or cicatricial contraction following the healing of the ulcer.

In case a gastro-enterostomy were performed before any dilatation has occurred as a result of the obstruction due to the presence of a duodenal ulcer, it is possible that the result might correspond to that observed in animal experiments.

Some years ago I observed a thickening of the circular muscle of the duodenum located usually a little distance below the entrance of the common duct into the duodenum as illustrated in Fig. 302, forming a kind of diffuse sphincter.

My former assistant, Dr. Edward Thuerer, examined the muscle of the duodenum in a large number of cadavers and found that in

recent cadavers this arrangement of muscle fibers could be regularly demonstrated. We also filled the duodenum in a number of cats and dogs, directly after they were killed, with melted paraffin and were able to demonstrate this same anatomic condition.

Fig. 302 gives a fairly clear idea diagrammatically of the condition found. In our experience no duodenal ulcer has been found below the location of this thickening of the circular muscle, which we have called a duodenal sphincter.

Whether this may have any influence upon determining the location of the ulcer, I am unable to tell.

In making a fluoroscopical examination of the duodenum, one can observe a contraction of the lumen of the intestine at this point in many cases.

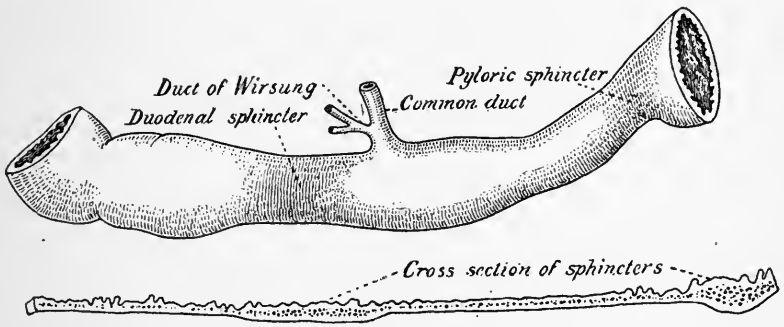


FIG. 302.—Diagram of pylorus and duodenum showing thick circular muscle fibers acting as sphincter of pylorus and at a point below the entrance of the common duct into the duodenum.

ACUTE PERFORATING ULCER OF THE DUODENUM.

The diagnosis of acute perforating duodenal ulcer is exceedingly difficult unless one has encountered a number of these cases personally. Perforation, according to statistics, occurs ten times as frequently in men as in women.

According to Codman the histories of cases of this class in the Massachusetts General Hospital show that in the vast majority of cases they are diagnosed as "acute appendicitis."

It is not difficult to mistake this condition also for perforating gastric ulcer, gall-stone colic with or without perforation, acute pancreatitis, renal colic and possibly ectopic gestation.

The violence of the attack should determine immediate surgical interference, because this will almost invariably result in recovery of the patient, while delay of even a few hours reduces the chances of the patient enormously.

The history is by far the most important element to be considered. In all other respects the evidence can be applied almost equally well to all of the conditions mentioned above.

A history of duodenal ulcer followed by sudden intense pain in the upper right quadrant of the abdomen, which is greatly increased upon

the slightest pressure, with hard, tense abdominal muscles, indicates the presence of actual or threatened perforation of a duodenal ulcer.

Operation.—A longitudinal incision should be made over the middle of the right rectus abdominis muscle, which should be split lengthwise. Upon incising the transversalis fascia some fluid and gas usually escapes immediately, confirming the diagnosis. It is best to make a very long incision in order that it may be possible to sponge away the fluid and to close the opening in the intestine without causing undue traumatism to the tissues.

It is wise to apply a large gauze tampon wrung out of warm normal salt solution so placed that there can be no future soiling. The fluid is then carefully sponged away.

The opening in the intestine is located and closed by placing the end of a finger over it. Then a stomach-tube is introduced and the contents of the stomach siphoned out in order that this may not leak through the opening into the peritoneal cavity.

If the opening is very small, a circular silk suture may be applied about the edges of the opening and tied to bring the edges together. Then one or two rows of sutures of fine silk are applied so as to cause the suture line to extend in a transverse direction to prevent further narrowing of the lumen of the intestine. A small piece of omentum is sutured over the part of the duodenum involved.

When this has been accomplished, careful gastric lavage is made with water at a temperature of 105° to 110° F., in order to remove any blood or mucus which may have accumulated in the stomach during the operation. It is usually well to examine the appendix in these cases, because acute appendicitis has occurred simultaneously in one of our cases, and in several others with perforation of a duodenal ulcer.

If the ulcer is extensive and the operation is performed soon after the perforation occurred, one may add gastro-enterostomy to the operation just described, but if there is any doubt about the patient's condition being sufficiently good to bear the shock of the operation, it is better to postpone this portion of the operation to some later time.

A fine feeding tube may be inserted through the stomach-tube and passed through the pylorus and 10 to 15 cm. beyond the point of the ulcer in the duodenum, through which predigested liquid food can be introduced for a week or longer after the operation until the ulcer has had time to heal thoroughly. The wound is closed with the exception of a small space through which one or more cigarette drains are passed into the kidney pouch. The same after-treatment is carried out after operations for chronic duodenal or gastric ulcer. Unless a feeding tube has been inserted it is best to nourish the patient for several days by the use of exclusively rectal alimentation, and then to begin giving alkalinized liquid nourishment by mouth, and later following the diet list described above.

CONGENITAL HYPERTROPHIC PYLORIC STENOSIS.

By ROBERT E. McKECHNIE, M.D.

Various names have been given for this condition, among which we find hypertrophic pyloric stenosis of infants, congenital spastic pyloric stenosis, congenital pyloric stenosis, spastic hypertrophic pyloric stenosis, etc. The name which, besides being eminently descriptive of the condition, agrees most nearly with the views of modern observers, as confirmed by their experience, is congenital hypertrophic pyloric stenosis.

The earliest record of an example of this disease was unearthed by Osler,[1] and is contained in *Cases and Observations by the Medical Society of New Haven in the State of Connecticut, 1718, by Hezekiah Beardsley.* The following description of the case gives an undoubted picture:

"A child of Mr. Joel Grannis, a respectful farmer in the town of Southington, in the first week of its infancy, was attacked with a puking, or ejection of the milk, and of every other substance it received into its stomach almost instantaneously, and very little changed. The feces were in small quantity and of an ash color, which continued with very little variation till its death. For these complaints a physician was consulted, who treated it as a common case arising from acidity in the prima via; the testaceous powders and other absorbents and correctors of acid acrimony were used for a long time without any apparent benefit.

"I was at first inclined to attribute the disorder to a deficiency of bile and gastric juices, so necessary to digestion and chylification, joined with a morbid relaxation of the stomach, the action of which seemed wholly owing to the weight and pressure of its contents, as aliment taken in small quantities would often remain on it, till, by the addition of fresh quantities, the whole, or nearly all, was ejected; but his thirst, or some other cause, most commonly occasioned his swallowing such large draughts as to cause an immediate ejection, and oftentimes before the cup was taken from the mouth.

"A number of the most respectable medical characters were consulted and a variety of medicines were used to little or no effect. His death, though long expected, was sudden, which I did not learn till the second day after it took place. This late period, the almost intolerable stench, and the impatience of the people who had collected for the funeral prevented so thorough an examination of the body as might otherwise have been made. . . .

[1] Am. Jour. Dis. of Children, 1911, ii, 159.

"I next examined the stomach, which was unusually large, the coats were about the thickness of a hog's bladder when fresh and distended with air; it contained about a wine pint of fluid exactly resembling that found in the vesicles before mentioned, and which I supposed to have been received just before its death. The pylorus was invested with a hard compact substance, or scirrhosity, which so completely obstructed the passage into the duodenum, as to admit with the greatest difficulty the finest fluid; whether this was the original disorder, or only a consequence, may perhaps be a question. In justice to myself I ought to mention that I had pronounced a scirrhosity in that part before the child's death."

Williamson[1] published the account of the second case, and a third case was reported by Dawaski in 1842. Then followed forty-five years during which no other case seems to have been observed. Then in 1887 Hirschsprung of Copenhagen reported 2 cases before the German Pediatric Society. Following this the profession seems to have become slowly aware of the existence of this condition and cases began to be reported. Thus in 1906 there had been reported 121 cases. At this time, dealing with a series of 113 cases Ibrahim states that 50 of these had been reported in Germany and 49 in Great Britain. As evidence of an increased awakening in the subject, in the next two years Ibrahim had collected a series of 400 cases and at the present time reports of cases are of frequent occurrence in the journals. This shows that the disease is of comparative frequency and merits a separate treatment in any surgical work.

That the disease is still frequently overlooked is suggested by Coombe,[2] from the fact that 6 out of 20 cases reported by Hutchinson in private practice, were the children of medical men. Thus 30 per cent. of these cases of Hutchinson's were in medical households. If we estimate 1 physician to 1000 of the population or one physician's family to 200 other families it would mean that this disease is 30 times more prevalent in doctor's families or else that it is 30 times less likely to be discovered in non-medical families. This latter must be the more reasonable to believe, and, being accepted, means that an immense number of these cases pass on to a fatal termination undiagnosed.

It occurs in the earliest weeks of life. Thus Pfaundler states that 50 per cent. of cases began to show symptoms between the fourth and fourteenth days, 25 per cent. between the second and third week and 25 per cent. between the third and sixth week.

The infants, as a rule, are well developed at birth and present nothing abnormal. A majority are first-born as well as a majority being males. Thus Holt[3] noted 49 males to 8 females. In his same series there were 52 breast-fed children to 5 fed artificially, a point to be remembered in the discussion on the causation of the condition and rather eliminating indigestion from faulty feeding as a causative factor.

[1] London and Edinburgh Jour. Med., 1841.
[2] Ann. Surg., 1911, liv, 167.
[3] Murphy's Clinics, No. 1, vol. ii, p. 157.

Normal Anatomy.[1]—Although the pyloric canal is by no means constant in form, and undergoes striking changes in accordance with later physiological conditions of the stomach, there is no part of the stomach which is more definite and distinct. The pyloric canal is a cylinder about one inch in length, and in a full-term child is generally found contracted and its lumen filled with longitudinal folds of mucous membrane. During life the pyloric canal is kept closed except during digestion, when it is periodically relaxed to allow the passage of acid gastric contents into the duodenum. If the contents are too acid, the quantity allowed to pass is lessened and the pylorus does not again relax until the contents in the duodenum have been neutralized by the alkaline juices there. This constitutes the duodenal reflex.

The pyloric canal is characterized by the great development of both longitudinal and circular muscular fibers. These latter completely surround the pylorus and constitute the sphincter. The longitudinal fibers take their origin in the wall of the pyloric end of the stomach and become more numerous as they reach the pylorus and there form a distinct longitudinal coat. The more superficial fibers pass on to the duodenum, while many of the others spread out in the form of divergent fasciculi, some of which reach to the submucosa. Thus the longitudinal fibers have an action antagonistic to the sphincteric fibers and act as a dilator of the pylorus when the nervous mechanism concerned in inhibition brings about a relaxation of the sphincter. Specimens of the pyloric canal of a full time fetus and of the child, show very distinctly that there is no sudden or abrupt transition between the muscular substance of the sphincteric cylinder and that of the sphincteric ring, but the fasciculi of the latter are quite cut off from the circular muscular coat of the duodenum by a distinct connective-tissue septum.

In discussing the action of the musculature of the pyloric canal, Stiles quotes Professor Cunningham: "The question which naturally suggests itself is whether the entire length of the sphincteric cylinder is to be reckoned, with the expelling or with the retaining forces of the stomach, or whether it is to be regarded as acting in both ways, and the sphincteric ring as being alone endowed with a continuous sphincteric function. Clinical evidence would seem to point to the entire muscular cylinder being under certain circumstances employed as a sphincter and thereby closing the whole length of the pyloric canal, against the entrance of material from the stomach. In these cases of pyloric stenoses in the infant, which of late years have attracted so much attention, it is not the sphincteric ring alone which is at fault and prevents the passage of the gastric contents into the duodenum. The circular musculature of the entire length of the pyloric canal, by its spasmodic contraction, leads to the closure of this section of the stomach."

Pathological Anatomy.—Pfaundler[2] in 1897, in criticising Stern's operation for this condition, came to the conclusion that there is no

[1] Stiles: British Med. Jour., October, 1906, p. 943.
[2] Hill: Surg. Gynec. and Obst., 1914, p. 616.

warrant for assuming the existence of an organic congenital pyloric stenosis. He believed that in the cadaver of an infant, a permanent contraction of the musculature at the pylorus can persist after death, which may appear as a hyperplastic tumor obstructing the lumen. And thus he started the spasm theory.

Cantley,[1] while accepting the view that there is such a condition as pyloric spasm in infants, says there is no evidence that spasm could cause hypertrophy. Spasm of the pylorus does occur at all ages, but it does not produce the condition of hypertrophy which is peculiar to the first few weeks of life. Recovering from pyloric spasm under medical treatment, in some cases mistaken for true hypertrophy, has led to an unduly favorable estimate of the value of medical treatment in true hypertrophy. True hypertrophy varies from a degree which is fatal, unless relieved surgically, to a slight hyperplasia which is compatible with life. To those who have seen both the clinical picture, and the operative, and postmortem findings, in these cases, there is no longer any question about the existence of a definite organic obstruction as the cause of the clinical picture, and it is also quite as clear that the only hope of relief in well-defined cases is some surgical operation which will overcome the obstruction.

This statement may seem to be too sweeping in the light of the statistics published by those who have employed the medical treatment. In the Schorstein Lecture (1910) by Robert Hutchinson, are quoted 19 recoveries out of 21 cases, 11 out of 12 and 30 out of 32, with medical treatment; but I do not think we can find similar favorable results furnished by the American practitioners. And even among the English writers we find the adoption of medical treatment discouraged. Thus at a meeting of the Royal Society of Medicine, Section for Study of the Diseases of Children, a specimen was shown from a case which had died from the condition we are discussing. Dr. Cantley, the chairman, remarked that it was a good illustration of one of the usual results of attempting to cure the condition by medical means, and that there were still many people who supported the view that a cure could be obtained by that means.

Holt[2] does not believe in persistent spasm of the pylorus without hypertrophy, and says that it would be well if the term "pylorospasm," as defining a group of these cases, were dropped from our nomenclature. He thinks it is responsible for neglect of operation when operation might have saved life. He also states that definite persistent spasm of the pylorus without hypertrophy is yet to be proved.

At operation, or postmortem, there is found a tumor consisting of a firm olive-shaped body, roughly one-half to three-quarters of an inch in length, covered by smooth, glistening peritoneum. There is no external evidence of inflammatory reaction and no attempt at fixation. This tumor has the firmness of cartilage, is never soft or pliable, and in no case was its consistency such as to make the finding questionable,

[1] British Med. Jour., February, 1908, p. 323.
[2] Jour. Am. Med. Assn., 1914, lxii, 353.

no case in which a gradation could be made out between a tumor mass and a mere thickening of the part involved or between the tumor mass and the stomach and duodenum. It was always sharply defined. This tumor is formed entirely by the hypertrophied circular muscle fibers of the pylorus. The mucous membrane lies in longitudinal folds in the lumen and is much thickened and arranged in a more or less spiral manner. The pylorus is not absolutely closed but the tumor mass blocks the lumen as an enlarged prostate blocks the urethra. So in many cases food in small quantities may find its way past and so life be prolonged. That bismuth may at times be forced through or that a suggestion of a milk stool occur must not, therefore, rule out the diagnosis. It is particularly important that the roentgen ray as a diagnostic measure be limited to determining the rate of emptying the stomach, not the patency of the pylorus. To exclude a diagnosis of hypertrophic stenosis on the basis of the passage of bismuth is sure to lead to serious error.

So it may be conceded that sufficient patency may persist to maintain life, even after temporary total blocking has been evident. Only on this basis can we account for the recoveries that have been reported by competent observers. The recovery does not imply the disappearance of the tumor. There is nothing in the nature of hypertrophic stenosis that essentially predicates a permanent pyloric closure. No good reason has been given why these tumors should not ultimately disappear. They are not neoplasms, but simple muscular hypertrophies. The indication for operation is not strengthened by proving the permanency of the mass. The fact that it does not disappear quickly enough is the essential absolute indication for surgical interference.

Downes[1] gives the sequence of events which, in his opinion, leads up to the closure of the pylorus. The presence of the muscular hypertrophy reduces the lumen of the pyloric canal, and therefore, the stomach in order to empty itself contracts more forcibly than normal. This abnormal contraction soon causes the mucous membrane to become thickened and edematous, and assume a more or less spiral arrangement as it passes through the narrowed pyloric canal. The result is a valvular action which gradually produces complete closure. That the hypertrophy exists at birth, that it was formed before food could produce irritation and so provoke hypertrophy seems proved. Pfaundler states that 50 per cent of the cases develop between the fourth and the fourteenth days. Murphy[2] notes a case which started at the second day while McKechnie[3] had one with complete obstruction dating from birth.

As to the permanency of the hypertrophy and of the obstruction Ibrahim[4] states that by the examination of the stomachs of infants who have recovered under medical treatment, from what has been

[1] Holt: Jour. Am. Med. Assn., 1914, lxii, 353.
[2] Murphy's Clinics, vol. ii, No. 1, p. 157.
[3] Canadian Med. Assn. Jour., July, 1913.
[4] Am. Jour. Med. Sc., 1912, cxliii, 14.

clinically diagnosed as hypertrophic pyloric stenosis, and died from other accidental causes, he found that the pyloric hypertrophy still remained, but that there had been developed a compensating hypertrophy of the stomach walls.

Eagleson,[1] of Seattle, proved by skiagrams that in 2 cases four years after operation, and 1 case six years after, the bismuth was passing by the anastomotic opening and not by the pylorus. These two authorities would tend to contradict those advocates of medical treatment who presuppose that there will be an absorption of the hypertrophy and so a cure of the stenosis.

Symptoms.—The symptoms of a case of congenital hypertrophic pyloric stenosis are very definite, and few mistakes in diagnosis should be made. No laboratory tests or other procedures which rely on the services of a specialist, need be called on and the general practitioner is as well able to diagnose the case as the staff doctor in a children's hospital, if he only has the fundamental points of these cases in his mind.

The patient is an infant, from one day to six weeks old, oftener a male than a female; oftener a first-born than one later and oftener breast-fed than bottle-fed. The symptoms[2] usually begin abruptly and the mother can give the day and often the hour when they first appeared.

This apparently healthy infant begins to vomit its food, without apparent cause, and at the same time there is noted a corresponding diminution in the feces. The child does not look sick, and even in an advanced case one cannot help remarking the bright appearance of the face. There is no evidence of a gastritis, no tenderness over the stomach and the food does not act on reaching the stomach as it would if it there met an inflamed mucosa. Sometimes, when the stomach is already nearly filled, additional food will be followed soon by vomiting, but at other times food may be retained for most of the day, to be later all or nearly all returned. If the obstruction is not complete some feces will be passed, but in the majority of cases the stenosis will be so pronounced, when the case is once under way, that practically only bile and mucous in the form of a dark green paste will be occasionally found on the napkins. The vomitus will consist only of the food taken, bile is not found in it. But as bile is found in the scanty stool, at once the point of obstruction is suggested as placed below the stomach, but above the entrance of the bile duct into the duodenum. With the continuance of the obstruction, there will be dilatation of the stomach and a state of emptiness of the intestines. This gives a characteristic appearance to the abdomen, as the upper part is full and distended, while the lower half is empty and concave. Waves of peristalsis are easily provoked in the stomach by manipulations or by giving a drink to the child.

[1] Paper not published. Read at the meeting of the North Pacific Surgical Association, at Vancouver, 1913.

[2] Holt: Jour. Am. Med. Assn., 1914, lxii, 353.

Following the beginning of the symptoms, there sets in a progressive loss of weight until finally the child presents a picture of extreme emaciation.

In a given well developed case, if careful record is taken of the amounts of liquids given, and care is taken to catch what is vomited, and an allowance made for what will be absorbed by wipes or towels, it will be found that the vomitus about equals the ingesta. The vomiting is apparently not accompanied by nausea, as there is no pallor or sweating and after the stomach is emptied the child looks as bright as before, and is quite ready to be fed again.

A record should be kept of the weight which will show a steady daily loss.

The urine is greatly reduced in amount, owing to the diminution in retention of fluids. Cases of anuria have been noted and a diagnosis of renal trouble made, the vomiting being considered uremic.

In addition, a tumor may be felt in the region of the pylorus in the majority of cases. Thus Marsh[1] notes that he found it in 4 out of 6 cases. A big liver may so overhang the pylorus as to shield it or if the infant is crying, the rigid muscles may hide it; but patience and gentleness will usually find it. It lies to the right of the vertebral column, about one and a half to two inches above the navel. As it is freely movable, it recedes before the examining finger and can be gently touched and felt as a small rounded and hard body. It feels like a small hard gland, and at the operation one is surprised to find it much larger than palpation has suggested.

McCracken[2] pointed out that, "as the emaciation was due to actual starvation from obstructed pylorus in an otherwise healthy organism, it was not surprising that this wasting showed certain almost diagnostic features in the face, abdomen, and nature and color of the skin, which distinguished it from cases resulting from true toxic wasting diseases. Peristalsis was fairly uniform in all cases at slightly over three and a half waves per minute, and in a case under suspicion if one saw a slight pucker of brows and flicker on the upper lid recurring about that rate, one would on gently exposing the epigastrium see the peristalsis. Mothers, though as a rule quick at observing epigastric swellings from other causes, were seldom the first to observe this phenomenal wave. Sometimes peristalsis was fickle; from half an hour to an hour after feeding was, he found, the likeliest time for observing it; in one case, kept under the closest observation, peristalsis was only seen once and that by chance. It was of importance, in all suspected cases, to find out if there was or was not a lump at the pylorus; and if unable to decide otherwise one was justified in giving an anesthetic, though cautiously, because in some cases acetone was present; but putting the infant in a warm bath, as suggested by a late resident of theirs, had always been sufficient to soothe the child, overcome muscular rigidity, and allow of a satisfactory and satisfying examination being made. Sum-

[1] Jour. of Children's Dis., 1911, viii, 53.
[2] British Med. Jour., March, 1912, p. 487.

ming up the symptomatology, vomiting, wasting, and constipation were indications of possible hypertrophy; suspicion ought to be intensified if these occurred in a first-birth and male infant. Visible peristalsis and a tumor at the pylorus were the rivets which clinched the diagnosis. Of these two, the tumor was the more important; either of the two by itself was an indication for medical treatment; but in the absence of both, one was not at the present date ever justified in making a diagnosis of pyloric hypertrophy. The stenosis at the pylorus was only partially due to hypertrophy of the circular fibers; it was augmented by the gastritis in the vestibule and pyloric canal, accumulation of mucus in the vestibule, and probably by superadded spasm; and the last three factors accounted for the complete blocking which sometimes occurred. The cause of this hypertrophy was not yet determined."

Pyloric stenosis usually results fatally in from six to ten weeks. In a certain portion of recoveries evidence of incomplete obstruction persists for months or years.

Treatment.—Owing to the teachings of Pfaundler, that the condition was not due to a genuine hypertrophy but to a spasm of the pyloric canal, treatment was entirely medicinal at first, accompanied by efforts at giving an easily digested and non-irritating diet, and by lavage to get rid of the hypothetical irritating stomach contents. Indeed, Marsh states that the German school to this day practically never operates. This teaching apparently has influenced the English school. Thus Marsh[1] quotes $91\frac{1}{5}$ per cent., recovered without operation. Other English statistics could be produced with much the same results. The weak point in these cases is that the condition was not proved, since the observer had no opportunity to verify his diagnosis, by either operation or postmortem. In the light of knowledge, gained by surgeons, it is impossible to believe that so large a number of cases could have been true cases of congenital hypertrophic pyloric stenosis, or even of the type in which we could suppose that the hypertrophy was but slightly developed; and clinical evidence is not forthcoming, to prove that pylorospasm is so prevalent a condition in infants, as to be able to produce so large a number of cases as is quoted by various authors. Hence we are drawn to the conclusion, that a certain group of cases which contain some irritating lesion of the stomach have been wrongly included under the head of congenital hypertrophy.

However, with any given case, the treatment resolves itself into either medical or surgical. Both the German and the British schools incline toward medical treatment although surgical treatment is being more practised and recently with good results.

McCracken[2] writes as follows: "The aim of all treatment was to promote the passage of chyme from stomach to intestine, and thus permit of absorption. This could be done surgically, but if one relieved gastritis, subdued spasm, and periodically removed the stringy mucus, then in a little time chyme, if free of coarse curd, could in most cases

[1] Jour. of Children's Dis., 1911, viii, 53.
[2] British Med. Jour., March, 1912, p. 487.

pass naturally through the pylorus; and these points could be obtained medically by stomach washing and judicious feeding. This line of treatment should be tried first in all cases, and sensible rules for guidance are given in all text-books. Unless the patient were in articulo mortis, one should never despair, of any case; but the development of some intuitive instinct toward an early diagnosis of this condition was 'a consummation devoutly to be wished,' by everyone who had much experience in its treatment. In a case under medical treatment, once peristalsis has been seen and a lump felt, one ought never to elicit or feel for either symptom again, and should look to it also that no one else did; all manipulation must of a necessity stimulate the very spasm which the treatment aimed at subduing. It was notorious that better medical results were obtained in private practice than in hospital. One authority had pointed out that these cases became, 'hospitalized,' an indefinite status too often seen in marasmic infants; but probably their being 'lionized' accounted for a good many of the disappointments. In Germany good results had been obtained by less washing than we practiced, but keeping warm poultices constantly over the epigastrium.

"Dent[1] apparently represents the transition from medical to surgical views on treatment as in the following extract. "In some mild cases medical treatment might cure it; but if they waited for the establishment of all the classical symptoms before operating, the percentage of mortality would be even higher than it was now, whereas if operation were done on many cases before the symptoms grew serious the results would be still better. Probably medical treatment when the child was not doing well was rather more dangerous than surgical."

Holt[2] gives perhaps the most impartial discussion on this vexed question of treatment and points out that there are medical risks as well as surgical risks. Among medical risks are acute inanition, slow inanition or marasmus, during which state the physician frequently does not realize on what thin ice he is skating; risk from intercurrent disease attacking an infant of low resisting power and lastly risk of sudden death, unexpected and unaccountable.

And if these medically treated cases do get well without operation, do they completely recover or does the lesion persist?

Holt quotes seven of his own cases which recovered under medical treatment, and whose after histories were so good that he concludes that the tumors were absorbed. But Downes, Marsh and others have proved by postmortem findings on children who have died of other ailments, after recovering through medical treatment, that the tumor persists. Eagleson also by bismuth meals and skiagrams proved the persistence of the obstruction, years after cure by operation. So it seems probable, that the tumor persists after apparent cure by medical treatment. And it has been shown by other observers, that cases of malnutrition in adults, traced from infancy to adolescence, suffer

[1] British Med. Jour., March, 1907, p. 627.
[2] Jour. Am. Med. Assn., June, 1914, p. 2015.

from a persisting congenital hypertrophic pylorus, which has later on been proved and rectified successfully by operation.

Surgical risks are plainly seen, shock, non-union from poor nutrition, exhaustion due to digestion not reëstablishing itself soon enough, accidental risks from faulty technic as hemorrhage, sepsis, obstruction, etc. But shock is low in infants and the technic has improved. Even if the surgical risks are considerable they are short, while the medical risks are prolonged and the dangers multiply with the duration of the symptoms.

Given an early diagnosis, a patient in private practice, under conditions which make the best medical treatment possible, operation may not in most cases be required; but in hospital practice, in cases seen later, in those with the most acute symptoms who are losing rapidly, and (lastly) when circumstances do not admit of the best medical treatment, there is no question but that immediate resort to surgery offers a better chance of recovery. To persist with medical treatment, week after week, when forcible vomiting and marked peristalsis are either continually present or keep recurring, when the weight shows only a slight loss, seems to be incurring far greater risks with the child than those of operation.

The crux of the whole question between medical and surgical treatment of pyloric stenosis seems to be—are the symptoms and conditions such as to make it probable that the patient will or will not live long enough for the pathological condition to subside?

If the child is in fairly good condition, if it is not losing weight rapidly, if some food in the stools proves that the stenosis is not absolute, and if in addition the environment be suitable with proper hygienic surroundings and no lack of suitable food and skilled nursing, then one is justified in recommending medical treatment.

If this treatment fails to check the downward course of the case, then one is not justified in waiting till the case is almost hopeless, before deciding on an operation. Surgery should be given a chance while there is yet a reasonable hope of success. This decision will usually lie with the family physician, who will sometimes find it hard, on account of partial remissions giving rays of hope; but if in spite of these remissions the general tendency is downward, then he takes upon himself a serious responsibility if he delays in recommending surgery.

When the average case comes to a surgeon there is but little else to do but to advise operation. Seldom does a surgeon see a case in the early stages, too often he sees a picture of skin and bones due to starvation, with hardly power enough to turn its head or utter more than faint cries. Still, even in such cases operation is very often successful and should not be denied to the weakest.

As regards prognosis Holt states that mortality is about 50 per cent. by either medical or surgical treatment. This was in 1914, but already surgeons were announcing much more favorable results.

Thus Scudder,[1] in 1910, states that medical treatment is responsible

[1] Surg. Gynec. and Obst., September, 1910, p 373.

for 80 to 90 per cent. of deaths, while he quotes 1 death in fourteen of his own surgically treated and ends by saying, "Gentlemen, in view of the evidence, I believe that surgical measures should be instituted as soon as the diagnosis is made. Delay is dangerous."

This attitude is the one adopted by the most advanced men of the profession today as regards appendicitis. When first advanced it was universally hailed as extreme but its adoption has led to an immense saving in lives.

As regards the adoption of a similar rule in regard to congenital hypertrophic pyloric stenosis, it should be pointed out that the mortality of cases treated medically will remain constant, 50 per cent. according to Holt, 90 to 80 per cent. according to Scudder. In surgery it is different. Technic has improved and men have improved in their own technic so that now there are a large number of surgeons capable of handling these cases with a minimum of risk. Scudder, as we have seen, had in 1910 one death in 14 cases. Richter[1] in 1914 quotes 19 successful cases in 22 operated on, and other surgeons show like favorable results. These figures show that surgery gives far more favorable results than medical treatment. And if we remember that the majority of the cases treated surgically are about in extremis, after a prolonged course of medical treatment, it is self-evident that if all cases were referred to the surgeon for operation, as soon as diagnosed, the percentage of mortality would be still further lowered. It needs only a little further pressing of the argument, to reach the rule, that in the interests of the lives of such patients, the adoption of surgical treatment at the earliest possible moment should be advised.

But if medical treatment be decided on it will consist of lavage and careful feeding. The stomach should be washed out twice a day with water at 112° F. to remove irritating particles of food and if possible the stringy mucus blocking the pylorus. Breast milk is the best food procurable but should not be rich in fat or if not obtainable a modified milk low in fat should be given. As to the time and quantity, this varies with the patient, small quantities and often being better for some, while others can take one to two ounces every three to four hours. If the case is greatly prostrated, hypodermoclysis twice daily of normal saline solution may be used. Rectal feeding is of little avail. Drugs are useless.

Surgical treatment has evolved through various operations. Surgeons seemed to think that these young patients would stand but little and accordingly divulsion of the pylorus, pyloroplasty, etc., were early tried as being less dangerous than gastro-enterostomy. But shock does not often follow operations on infants, and experience has proved that the operation of choice today, posterior gastro-enterostomy, can be performed about as quickly in skilled hands as these other operations with vastly better results. Accordingly today this operation is the one almost universally adopted. The technic does not differ from that of

[1] Jour. Am. Med. Assn., 1914, lxii, 353.

the same operation performed on the adult, but owing to the smallness of the parts it takes more delicacy of touch and handling. It will be found that no superabundant mucosa need be cut away from the margins of the jejunal opening.

Sometimes considerable trouble is had with the bowels escaping through the wound at the time of operation. If the incision is made high up this tendency will be minimized. After operation it has sometimes happened that the wound has given way, owing to early absorption of the catgut layers or the sutures cutting through the postoperative edematous fascia. It is therefore recommended, that instead of closing the skin separately with horse-hair or silkworm gut, the latter be used and placed first as through-and-through sutures, including all the structures of the wall. The various layers can then be approximated with plain and chromic gut and the silkworm gut finally tightened.

In the postoperative treatment, the first thing to be attended to is position. The trunk should be elevated to an angle of one hundred and thirty-five degrees from the horizontal, both to facilitate expulsion of gases from the stomach and also to prevent obstruction due to adhesions, if the jejunum is allowed to bunch itself up under the mesocolon. The upright position allows the bowel to drape itself as it should hang afterward.

Feeding should be started in four hours and although most authorities advise mother's milk as the most preferable, the danger of curds, blocking the anastomotic opening, has led others to prefer whey or barley-water for the first few days. One to three ounces can be given at three- to four-hour intervals with water between, although some children seem to do better with half an ounce hourly. Hypodermoclysis of 100 to 200 c.c. of normal saline solution is also important, as the tissues of these patients are starved for want of water, and it is good practice to give this just before the operation as well. Rectal feeding is of but little use. Castor oil can be given at the end of thirty-six hours. This is the treatment as recommened by Holt,[1] who concludes his article with, "Aspiration of the stomach to determine the degree and rate of emptying is of much assistance in deciding the frequency with which these children should be fed and the amount of food offered at one time. Its value is not appreciated."

Although posterior gastrojejunostomy is the generally accepted method of treating this condition, the procedure developed by Dr. Alfred A. Strauss, of the Michael Reese Hospital, Chicago, bids fair to supersede it. His record of only 3 deaths in 101 operations has nowhere been nearly equalled. Reports from other surgeons are almost uniformly favorable. His technic will be described later.

Dr. Strauss divides his cases into medical and surgical by *x*-ray observations. Thus in 137 cases he classed 101 as surgical and 36 as medical. The latter did uniformly well in treatment and the former,

[1] Jour. Am. Med. Assn., 1914, lxii, 353.

as before stated, had but 3 deaths following operation. Those cases in which one-half or more of the bismuth milk had not passed the pylorus at the end of four hours were classed as surgical.

The fluoroscope, as distinguished from the skiagram, is largely depended upon in making the diagnosis. The position of the infant while under observation is important. If it be lying on its back, the milk does not gravitate toward the pylorus, but if rotated toward its right side the milk comes into the pyloric antrum and initiates movements which Dr. Strauss describes as characteristic. Peristaltic waves force a small amount of the milk through the pylorus, which thus clamps down tightly and is followed immediately by "peculiar and characteristic, snake-like, rhythmic peristaltic contractions in the pylorus, which contractions are independent of the rest of the stomach. This is absolutely pathognomonic of the condition."

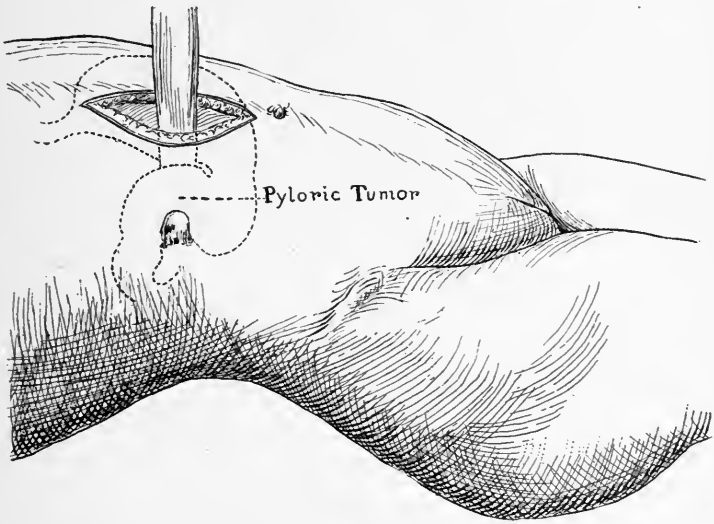


FIG. 303.—Small ribbon-shaped hook passed around tumor, which is drawn out through the incision. (Strauss.)

The fluoroscopic examination is repeated in two hours, and again at the end of four, roentgenograms being also taken at these two last examinations.

The operation is essentially a pyloroplasty, which can be performed much quicker than a gastro-enterostomy, and without exposing the stomach and bowels. Shock is accordingly minimized both by the lessened exposure and the saving in time.

An incision about one inch in length is made through the right rectus, over the pylorus, through which opening the forefinger and a ribbon-shaped hook are introduced (Fig. 303). The pyloric tumor is then hooked through the opening. A longitudinal incision is then made through the tumor, half way to the mucosa, and extending up into the

stomach wall a little. With the handle of the scalpel this incision is broken through to the mucosa, thus avoiding the wounding of the mucosa by the cutting edge of the scalpel (Fig. 304).

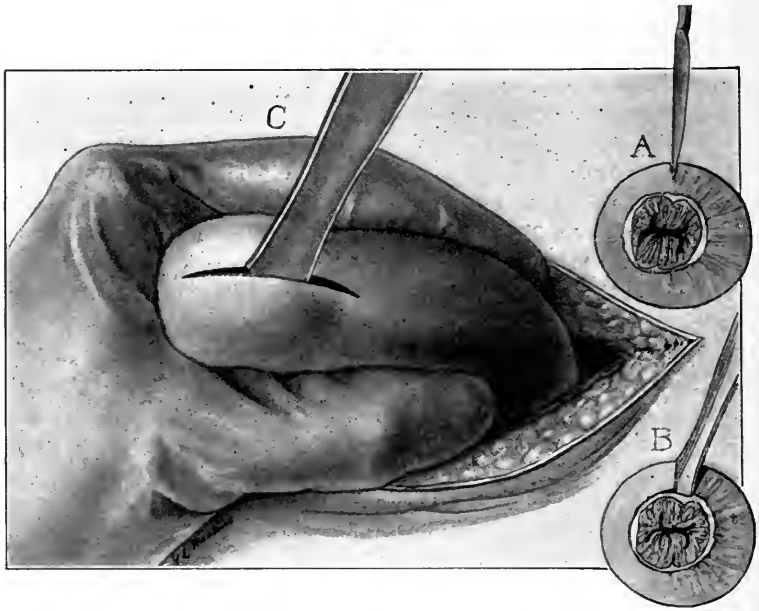


FIG. 304.—*A*, transverse section, showing incision through outer layers of tumor with sharp end of scalpel. *B*, transverse section, showing handle of scalpel breaking through deeper layers of tumor down to mucosa. *C*, longitudinal incision carried well beyond tumor on stomach side, showing length of incision and handle of scalpel breaking through to mucosa. (Strauss.)

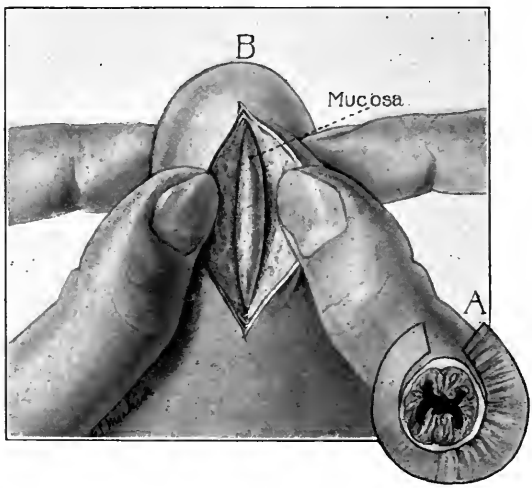


FIG. 305.—*A*, transverse section, showing mucosa separated from muscularis. *B*, method of spreading tumor which separates mucosa from muscularis and also breaks all muscle fibers down to duodenum. (Strauss.)

The mucous tube is then shelled or stripped out by everting the divided pyloric muscle and peeling the mucosa back, except for a linear attachment posteriorly (Figs. 305 and 306).

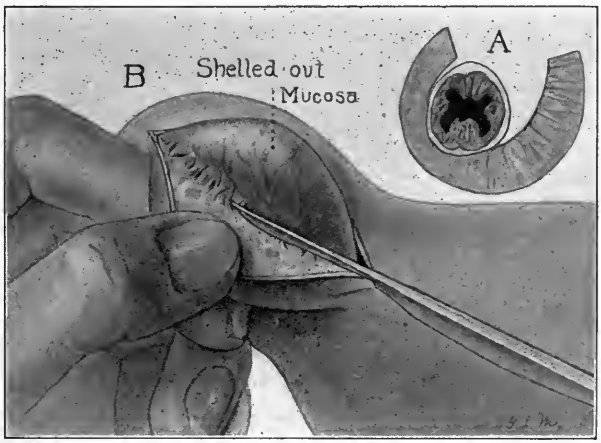


FIG. 306.—*A*, transverse section, showing shelled out mucosa. *B*, method of separating mucosa from muscularis. (Strauss.)

The various steps in the operation are shown in the accompanying illustrations of Dr. Strauss's.

The method of utilizing the hypertrophied muscle is shown in Figs. 307 and 308, which show the construction of a roomy pyloric muscula-

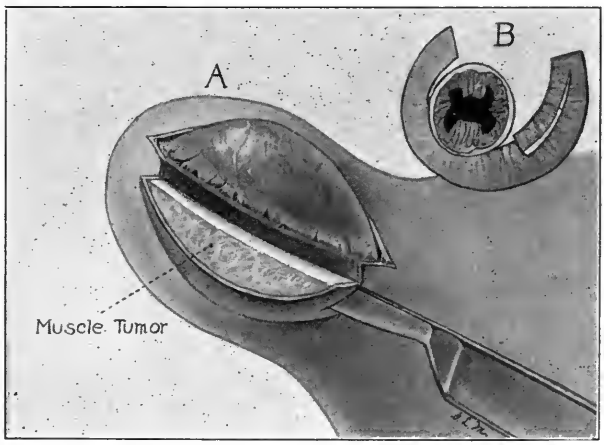


FIG. 307.—*A*, method of splitting muscle tumor with knife. *B*, transverse section of same. (Strauss.)

ture and the unfolding of the mucous tube. Five black silk sutures are used to approximate the flaps. The site of the operation is then covered by the free edge of the omentum which is sutured in place.

The omentum besides covering a raw surface shortly gives additional blood supply to the divided flaps.

The pylorus is then dropped back into the abdomen and the abdominal wound closed. This whole operation can be done in ten minutes.

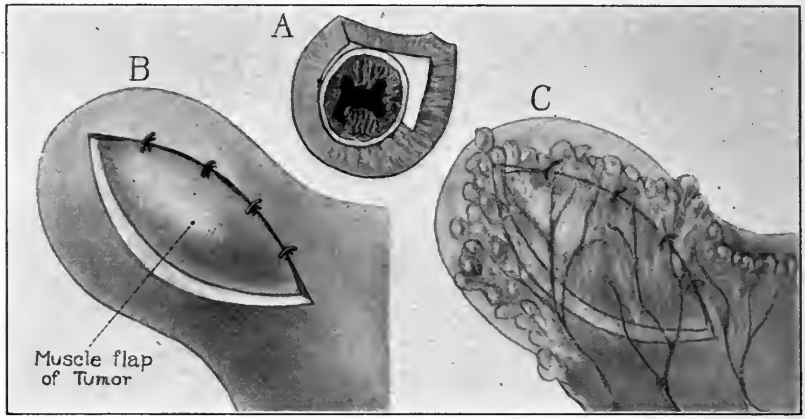


FIG. 308.—*A*. transverse section, showing muscle flap sutured on to opposite side. *B*, muscle flap attached with interrupted suture. *C*, free edge of attached omentum brought over operated area. (Strauss.)

Another advantage of this operation is that the mucous membrane has not been opened and feeding can be begun almost at once. Dr. Strauss's method is one ounce of normal salt solution per rectum every three hours, as soon as the child is awake, one dram of mother's milk every two hours with one dram of water between. The feeding is increased until at the end of twelve hours one-half ounce of milk is given, at thirty-six to forty-eight hours an ounce every two hours and at the end of seventy-two hours the child is put to the breast regularly every two hours.

SURGERY OF THE GREAT OMENTUM.

By KENNETH A. J. MACKENZIE, M.D.

The development of the great omentum follows that of the bursa omentalis or omental pouch which is formed from the primitive mesogastrium. The latter is attached to the greater curvature of the stomach and grows out with that organ from the spine, becoming elongated and forming a space behind the stomach which becomes the lesser peritoneal sac, the entrance to which is the foramen of Winslow. At this stage the mid-gut is being greatly lengthened and coils upon itself, necessitating an increase in the width of the attachment of its mesentery. Both the large and the small intestines are now attached right and left to the vertebral column by a common mesentery; the gut rotates upon itself, the large intestine is carried in front of the small, and the cecum behind the liver, which descends, in the sixth month, into the right iliac fossa. The bursa omentalis first reaches as far as the greater curvature, but at a later period, it grows downward to form the great omentum, which lies in front of the transverse colon and the small intestine. The posterior wall of the bursa omentalis appears, at first, separate and distinct from the anterior layer of the transverse mesocolon. Fusion of these layers takes place, however, so that the great omentum appears not only to cover but to be intimately adherent to the transverse colon.

ANATOMY AND PHYSIOLOGY OF THE GREAT OMENTUM.

Anatomy.—From the greater curvature of the stomach and the transverse colon hangs, like an apron, a duplicature of the peritoneum, which overlies the coils of the small intestine and is termed the great, or gastrocolic omentum. Subject to great variations in size, it appears sometimes as a small film-like fringe, at others, as a formation redundant in size and length. Normally it is a delicate structure of symmetrical form, its lower border often serrated, the projecting end having fimbriated edges. The omentum is a peritoneal membrane and, however thin it may appear, four separate folds of peritoneum enter into its formation. In most cases the four layers are fused into two which enclose the omental bursa. The layer which drops from the anterior surface of the stomach, when it reaches the greater curvature, turns upon itself, ascends, and is reflected over the transverse colon, becoming fused with the transverse mesocolon and forming the posterior wall of the omental bursa. With the downward growth of the great omentum from the lower border of the stomach, the bursa

omentalis extends downward a variable distance between the layers of the omentum. In rare instances the space can be demonstrated in the adult showing the prolongation of the lesser peritoneal space downward between the layers of the great omentum.

The vascular supply of the great omentum is derived from the right and left gastro-epiploic arteries which form a rich plexus between its two anterior layers. Their veins empty into the portal vein. The lymphatic current is active in the omentum and its contents are swept into the glands on the greater curvature of the stomach. No nerves have been isolated in the substance of the great omentum.

Histology.—The omentum possesses a stroma of fine connective tissue containing many white elastic fibers distributed in the form of a fine interlacing network. Its meshes contain many small vessels, a variable deposit of fat, and a vast number of connective-tissue cells and nuclei. The microscope reveals in its tracery many germinating cells springing from the fixed cells of the connective tissue or its endothelial lining. These cells have been observed in the act of division and possess ameboid movement. It is believed that the omentum possesses a special function to produce leukocytes when they are needed in the economy for offensive or defensive purposes.

Mechanics or Movements of the Omentum.—The mobility of the omentum is governed by factors which may be extrinsic or intrinsic. Extrinsic influences are: (1) The movements of respiration; (2) the action of gravity; (3) the reactions of intra-abdominal pressure. Intrinsic influences are: (1) The peristaltic wave which imparts definite and constant movement with definite direction (it probably causes the omentum to twist and to insinuate itself into gaps in the abdominal wall). (2) The peculiar structure of the omentum, its smooth and slippery surface and pendulous position, impart to it a tendency to glide readily into any breach in the walls or toward perforations, strongly suggesting design for conservation. (3) A singular activity is observed in its relation to infections, namely, a tendency to deploy toward the zone of infection and to envelop it; this movement is like that of an octopus, its arms aloft to grope and reach toward its prey. (Proof of this is found in the fact that in the presence of multiple perforations of the intestine, the omentum has been known to throw out its fimbriated prolongations in various directions to protect all points.) (4) The omentum probably possesses a movement which is peculiarly its own. (5) The rich plexus of vessels held in the meshes of the omentum probably impart a definite movement. (6) The phagocytic activities, colossal at times, are said to impart a movement like that of a tide directed toward the hosts of invading bacteria.

Functions.—The great omentum acts as a splint to exert pressure upon the subjacent coils of intestine to hold them in place and rests as a buffer to protect the contained organs of the abdomen from shock without or within. Thus the force of a hard blow upon the abdomen could be spent upon the omentum and save the intestine

from contusion or rupture. Its gliding and sliding movements, together with its cohesive quality, cause it to be directed into apertures in the abdominal wall, closing them up. This function is well seen in stab wounds. Its rich vascular supply, and the loose network of veins that contains it, makes the omentum a reservoir for the storage of blood of special service when the pressure index is high, and the exigencies of the circulation require control. The veins of the omentum empty into the portal vein and any factor causing delay of the portal circulation instantly causes congestion of the veins and transudation follows. The omentum itself alone, under the stress of retarded venous circulation could readily give rise to ascites. This well-known fact in pathological anatomy forms the basis of the operation of omentopexy, originally designed by Talma, of Utrecht, for the symptomatic cure of ascites. The omentum has been known to furnish, through the medium of adhesions, the blood supply for organs or new-growths completely deprived of their circulation. This fact has been demonstrated in relation to fibroid tumors of the uterus and cysts of the ovaries shorn of their blood supply by twisted pedicles.

Absorption.—The omentum, through its bloodvessels and lymphatics, has great power of absorbing fluids and even solids. It is stimulated in this activity by the pressure of the abdominal muscles, the movements of the diaphragm and also by peristalsis. Normally the omentum plays the most active part in the absorption of all substances in the peritoneal cavity. If its endothelial lining be intact, absorption takes place through the lymphatics; if not intact, it takes place through the vascular system.

Phagocytic Role of the Omentum.—The peritoneum is exposed on all sides and at all times to the hazards of bacterial invasion and if the most effective barriers were not provided, abdominal disease would be the constant lot of man. The barrier that protects the organism is the omentum which can pour out, at short notice, countless hosts of leukocytes into the peritoneal cavity to combat invading bacteria. The normal blood of the peritoneum contains the neutrophiles which, in the presence of infection, assemble in large numbers on the omental surface and borders, collecting in large clusters and held together in the meshes of a fibrinous layer. The eosinophiles mingle in these masses with other varieties of cells. The experiments of Dudgeon and Sargent show that with the initial irritation of the peritoneum, the Staphylococcus albus appears before there is even any solution of continuity, and provokes at once a rapid formation of phagocytes. Their concentration at threatened points shows, when virulent organisms appear, that an offensive has begun.

Omental Buttress.—Associated with the phagocytic function of the omentum is the predilection to shield points of infection or irritation. Thus an infected Fallopian tube will be found instantly enveloped by a blanket of omentum which imprisons it completely, or, in like manner, a perforated appendix, in the shortest interval, will find its point of perforation firmly sealed by one of the fimbriated processes

of the great omentum. The rich exudative layer thrown out at the time, strengthens the barrier and resists further encroachments beyond it.

INFLAMMATORY DISORDERS OF THE GREAT OMENTUM.

Epiploitis. Omentitis.—This condition is nearly always part of a general peritonitis traceable to some definite lesion within the abdomen. Rarely will it appear that the process begins in the tissues of the omentum, but frequently it will be found that a local abdominal lesion has caused a local omental inflammation, the characters of which are identical. In such states the tissues of the omentum tend to proliferate actively and form nodes of granulation tissue which tend to coalesce and form masses large enough to be mistaken for new growths. This constitutes one variety of inflammatory tumor of the omentum. Another variety is made up of omental fabric rolled up in a knot and held together by a stroma of granulation tissue which imparts the sensation of a newgrowth, dense in structure. Such tumors form slowly, as a rule, but rapidly at times, and in acute cases, follow surgical operations. They pursue a variable course. (1) They disappear by gradual absorption of the exudate and the attenuation of the granulation tissue. (2) At times the tumor persists, its elements having become organized. (3) The tumor breaks down and an abscess forms in the center with dense walls of omental and granulation tissue. (4) The tumor becomes nodular and indurated having undergone interstitial fibroid degeneration with marked chronic features. These tumors not infrequently follow operations and have been traced to the use of non-absorbable ligatures and also to faulty technic, such as massive ligations during resection. They form attachments, at times, to the abdominal walls, and if not adherent, possess a striking degree of mobility.

Diagnosis.—The diagnosis of these disorders must be considered in relation to ovarian tumors with long pedicles, displaced organs, and any of the various tumors, benign and malignant, which involve the omentum.

Abscess of the Omentum.—Abscess of the omentum is nearly always the result of local lesions of the peritoneum, and infections of the appendix and Fallopian tubes are frequent causes. The formation of abscesses has also been traced to the use of non-absorbable ligatures. Occasionally an omental abscess takes place independently of peritonitis and local lesions of the abdomen.

Diagnosis.—Diagnosis is not usually difficult. The history furnishes the most important clue. A mass can usually be felt which may, or may not be movable. Pain is constantly present and a sensation of dragging, and when pressure is made upon the mass pain of a dull character is elicited. The dense walls will seldom permit the detection of fluctuation. A moderate degree of temperature is present and also a constant state of leukocytosis. The abscesses terminate

sometimes by forming adhesions to the walls of neighboring organs and perforating into the hollow viscera. Cases have been known to point externally and others to become permanently encysted and to undergo gradual absorption.

Treatment.—The proper treatment when the diagnosis is made is extirpation. Obviously it would be wrong to explore these abscesses with needles or trocars.

The study of the sequels of omental inflammation is very important because of the effects of movement upon the exudate in forming bands or adhesions with neighboring tissues. The drag which is exerted upon adhesions causes them to become hypertrophied and converts them into bands as thick and tense as whipcord, which endanger the organs, especially the intestines, by causing kinks, or even by acting as snares to seize exposed loops. Instances are on record where they have caused by traction, obstruction of the pylorus, the ureter and the common duct.

NEOPLASMS OF THE OMENTUM.

1. Inflammatory. (See Inflammation.)
2. Benign:
   - (*a*) Solid:
     - Lipoma, fibroma.
   - (*b*) Cystic:
     - Cystic lymphangioma: Cystic disease of the omentum associated with congenital cystic kidney.
     - Pseudo cysts: (I) Serous; (II) sanguineous; (III) peritoneal (inflammatory).
     - Retention cysts: (I) Lymphatic; (II) chyle.
3. Malignant.
   - (*a*) Solid:
     - Sarcoma, the different types including myxosarcoma. All forms have been described as affecting the great omentum developing as primary growths.
     - Carcinoma; all varieties have been identified but always secondary manifestations of the disease.
   - (*b*) Cystic:
     - Cystic sarcoma and other types of cystic malignant disease.
4. Teratoma:
   - Dermoids, fetal inclusions, embryonic cysts.
5. Parasitic cysts:
   - Hydatid disease of the omentum (echinococcus cysts).

Lipoma.—Lipoma must be studied apart from the inflammatory tumor which is very often made up of normal fat matted together in clumps. Small fat tumors are frequently observed. Occasionally they assume rapid growth stimulated by the rich vascular supply and attain enormous dimensions. Waldeyer and Spencer Wells reported two cases weighing sixty-three and twenty pounds respectively.

Fibroma.—Fibroma is usually found as a small dense encapsuled tumor and may assume rapid growth and attain great size. The omentum has been known to adopt tumors from neighboring organs, the circulation of which has been cut off by torsion of their pedicles. Thus the great omentum has been known to foster fibromata and cystomata of uterine and ovarian origin.

Simple Retention Cysts.—Simple retention cysts have been observed and also cysts of inflammatory origin with peritoneal investment. Sanguineous cysts have been noted as the result of trauma and imperfect hemostasis. The existence of large lymph circulation justifies the formation of serous and chyle cysts but it is doubtful that the latter can exist unless adopted by the omentum from the neighboring mesentery.

Cystic Lymphangioma.—The literature of these tumors has been enriched by Stillman, of San Francisco, in an excellent study which makes a review of upward of 20 recorded cases. The etiology is obscure. They are regarded by some authorities as being merely the dilatation of the lymph vessels of the omentum, by others, as endotheliomata, while others again regard them as strictly lymphangiomata. The cysts are found between the peritoneal layers and are numerous, thin-walled, tortuous and often elongated. They may be few in number or distributed throughout the omentum. The thin walls are transparent and lined within and without with endothelium. The fluid is usually clear, having, at times, very attractive tints. It is albuminous and coagulates. There is nothing to show that the cysts metastasize or invade neighboring organs.

Cystic Omentum.—Cystic omentum associated with congenital cystic kidney: A case of cystic kidney of extraordinary size and coloring which came under my observation was recorded by Bloodgood in the *Johns Hopkins Hospital Reports*. The omentum was extensively involved, and in a case only recently, while applying Rovsing's method of treatment to the cystic kidney, I found the omentum studded with cysts.

Sarcoma.—Sarcoma of the different types including myxosarcoma have been observed frequently. Bonamy reports 15 cases of primary sarcoma of the omentum in which 12 operations were performed. Five survived the operation for one year or more. I observed with the late Dr. J. M. Brook, of Portland, a case which, because of the acute overt symptoms and peculiar localization, was thought to be a case of acute appendicitis. Operation revealed a tumor occupying the free end of the omentum which was matted and adherent to the neighboring organs including the bladder. There was a good deal of free blood in the peritoneum and the lymph glands throughout were enlarged. The tumor was removed and was demonstrated to be myxosarcoma. The case afterward proved rapidly fatal. A few cases of primary endothelioma have been reported although the records do not seem to bear the stamp of authenticity. It is rather strange that there are no authentic cases of these tumors recorded.

in relation to a viscus so generously laden with the type of tissue peculiar to them.

Carcinoma.—Practically all forms of carcinoma have been described as affecting the great omentum although no authentic case of primary growth has been recorded. They either occur as metastases or as

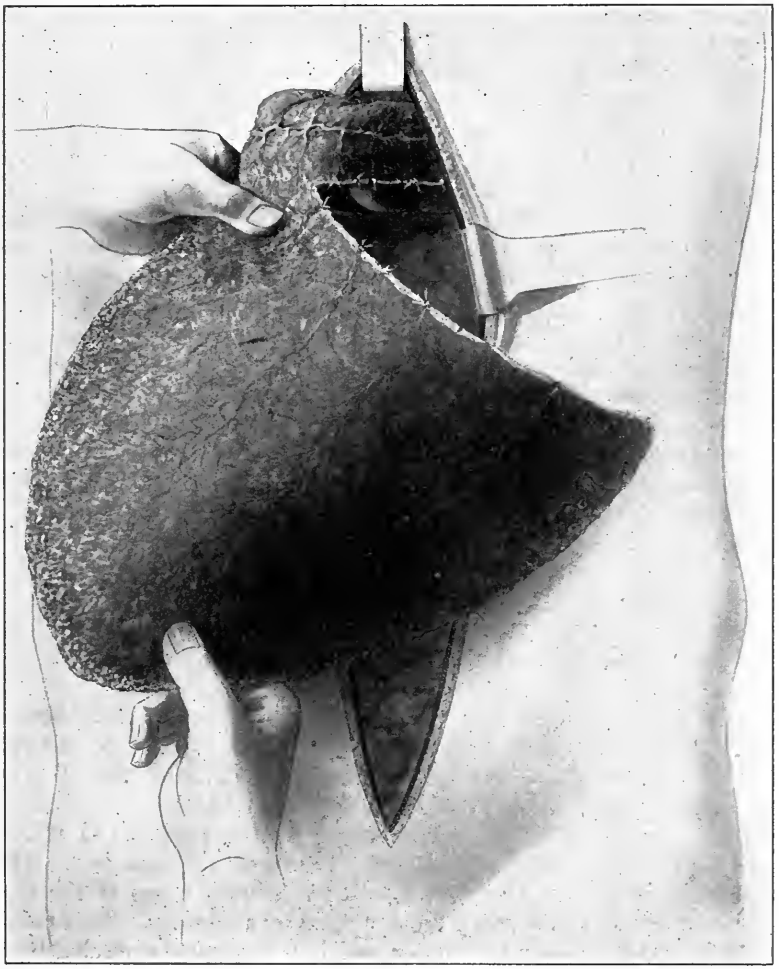


FIG. 309.—Omentum, the seat of cancer infiltration, resembling shield, showing scheme of resection.

extensions of the disease from neighboring organs. I observed, in 1895, a case of cancer which involved in its entirety a very large omentum. It was as if the entire omentum had been infiltrated with translucent wax solidified in its meshes. On palpation the omentum could be felt like a thick shield as dense as cartilage through the abdominal wall. Its rounded edge could be felt through the rectum.

Because of the pain that it caused, a surgical operation was performed and the incision for its relief extended from the ensiform cartilage to the pubes. It was sixteen inches wide and twelve inches in length and resembled a turtle back. It was probably a scirrhus which directly invaded the omentum from the stomach. (See Fig. 309.)

Cystic Sarcoma.—Cystic sarcoma and other types of cystic malignant disease have been reported but the records so far are immature. Cysts develop in connection with both sarcoma and carcinoma.

Teratoma.—This variety of tumor has been found in the great omentum but it is very doubtful that it occurs as a primary tumor. It is more likely that the omentum, with its predatory tendency, has appropriated the tumor from some neighboring organ, the normal habitat of the growth. The literature, however, shows seemingly authentic cases of dermoid and even fetal inclusions in the great omentum and embryonic cysts from the remains of fetal organs, such as the Wolffian and Müllerian bodies.

Parasitic Cysts.—Hydatid disease of the omentum is proved by the relative frequency of the disorder. I have observed 2 cases of echinococcus cysts of the great omentum both of which are recorded in the pathological reports of the Medical Department of the University of Oregon. In 1 case the major cyst, as large as a child's head, was in the omentum and smaller cysts were found in the liver and spleen and in the peritoneum above the bladder. They were successfully removed. In the other case, the major cyst was within the liver and smaller cysts were distributed in the peritoneum. The major cyst was treated successfully by marsupialization. Both cases developed in men of foreign birth.

Diagnosis and General Symptoms.—The tumors lie at, or below, the umbilicus and are pendulous, possessing a wide radius of lateral and upward movement. This range of movement is almost typical. In the case of the omental cyst referred to previously, the tumor could be swept from the right iliac fossa to the left hypochondrium, and also from left to right. The physical characters will always depend upon the nature of the tumor. Solid tumors may be smooth, nodular or lobulated, according to their character. Cystic tumors are round, elastic and smooth and are found to fluctuate on palpation. The movements of these tumors are synchronous with those of the diaphragm unless, of course, they are anchored by adhesions. Percussion reveals a dull note over the tumor and it is generally encircled by a resonant area. The subjoined table, which differentiates ovarian from omental tumors, will be found a general aid in diagnosis of tumors of the omentum.

Ovarian Tumors.	Omental Tumors.
Grow from below upward.	Grow from above downward.
Draw the uterus upward.	Force the uterus downward.
Range of movement lateral and downward.	Range of movement lateral and upward.
Easily mobilized downward.	Easily mobilized upward.
Movement not influenced by respiration.	Movement influenced by respiration.
Radius of movement narrow and limited.	Radius of movement wide and unlimited.

Operative Treatment of Tumors of the Great Omentum.—A few general principles are established. In all cases of benign growth of the omentum, where it is possible the tumor should be extirpated without unnecessary sacrifice of the omentum. This principle predicates that in the operative treatment of some benign tumors such as the cystic lymphangioma, the entire omentum may be removed. In all cases of malignant growth of the omentum, the entire omentum should be removed flush with its attachments.

These principles being borne in mind, the technic of the operation becomes of paramount importance. The operation should be performed bloodlessly, the vessels being always tied before their division.

Sutures of delicate catgut are applied to each vessel encountered by means of a fine curved needle, and carefully tied. This is done in detail across the entire area to be resected. Preliminary to the division of the omentum in resection, the part about to be cut should be compressed by a powerful hemostat of the Ferguson type with narrow blades. This displaces the fat of the omentum in both directions leaving a thin mesh of tissue which is readily seized and any oozing controlled. This process is continued throughout until the resection is completed. Thereupon the edges may be whipped together by delicate sutures, thus eliminating any raw surface to invite adhesions.

This technic is applicable to all operations upon the omentum and is designed to prevent the evils of the formation of adhesions and bands and inflammatory states which are well known to cause such astounding morbidity.

TORSION OF THE GREAT OMENTUM (OMENTOVOLVULUS).

Torsion of the great omentum is a rare condition. It is most frequently found in association with hernia, the inguinal variety predominating. Adhesions of the omentum within the sac is a constant concomitant although it is possible for torsion to take place without the association of hernia, and even without peripheral adhesions. It may be single, double or even multiple. When single it is usually in a hernial sac and the spiral may extend gradually upward until a great part of the omentum becomes involved. When double, one twist will be found in the sac and the other may be entirely independent in the body of the omentum.

Lejars defines two general classes of cases: (1) That favored by the descent of the omentum into the hernial sac to which it becomes anchored by adhesions; (2) that of torsion having no hernial association. In the first class, twisting may take place in two regions, within the sac (parasaccular) or near the colon (paracolic) (Fig. 310).

Richardson makes a clinical and anatomical classification. Of the clinical there are acute and chronic forms. The onset of the acute is violent, if not fulminating, resembling acute strangulation. It may refer to an acute torsion in a hernial sac, or one affecting a free, normal omentum. The chronic form has no definite symptoms;

it may be suspected if associated with an old hernia, especially an irreducible epiplocele. One can trace upward the outline of a distorted omentum corresponding to a zone of fulness and dulness, triangular in area, which extends to the transverse colon. The symptoms progress until torsion has finally reached the stage of blocking the circulation of the omentum when the symptoms of acute strangulation supervene.

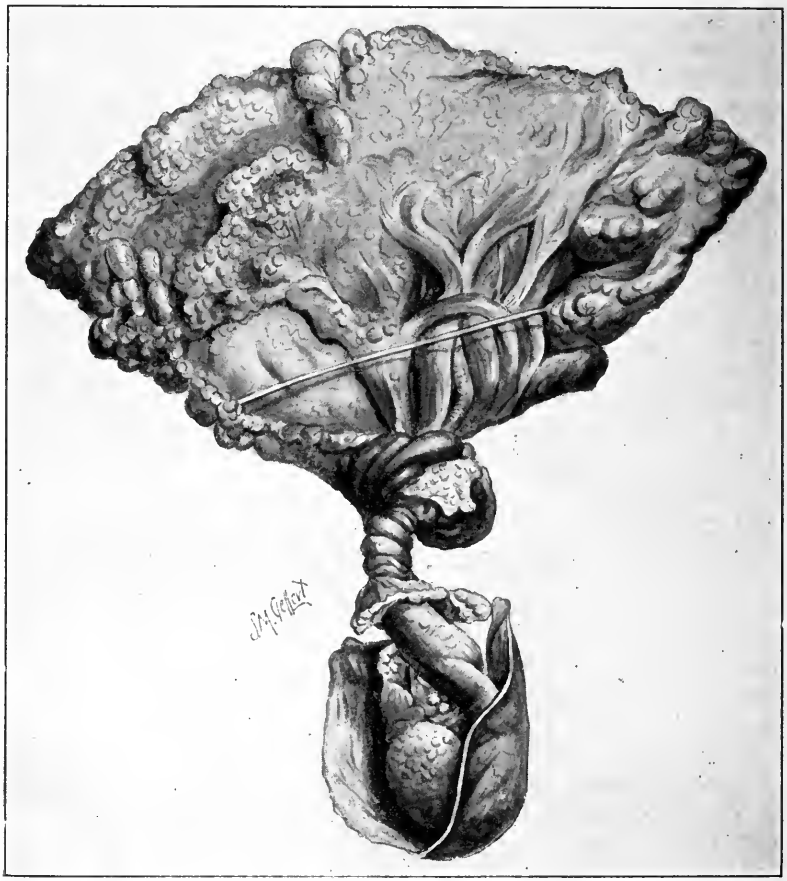


FIG. 310.—Illustrates the parasaccular and paracolic forms of omentovolvulus.

Of the *anatomic* there are three forms: (1) Intrahernial omentovolvulus: In this variety the point of torsion and the strangulated mass are within the confines of the hernial sac. It should be borne in mind that the omentum is strangulated by its own twist and not by a constricted hernial ring. (2) Intra-abdominal omentovolvulus: The point of torsion and the strangulated mass are within the abdomen, the latter, however, may extend into the sac. (3) Combined intrahernial and intra-abdominal omentovolvulus: There are two

points of torsion, one within the sac and one within the abdomen and, obviously, two corresponding strangulated omental masses.

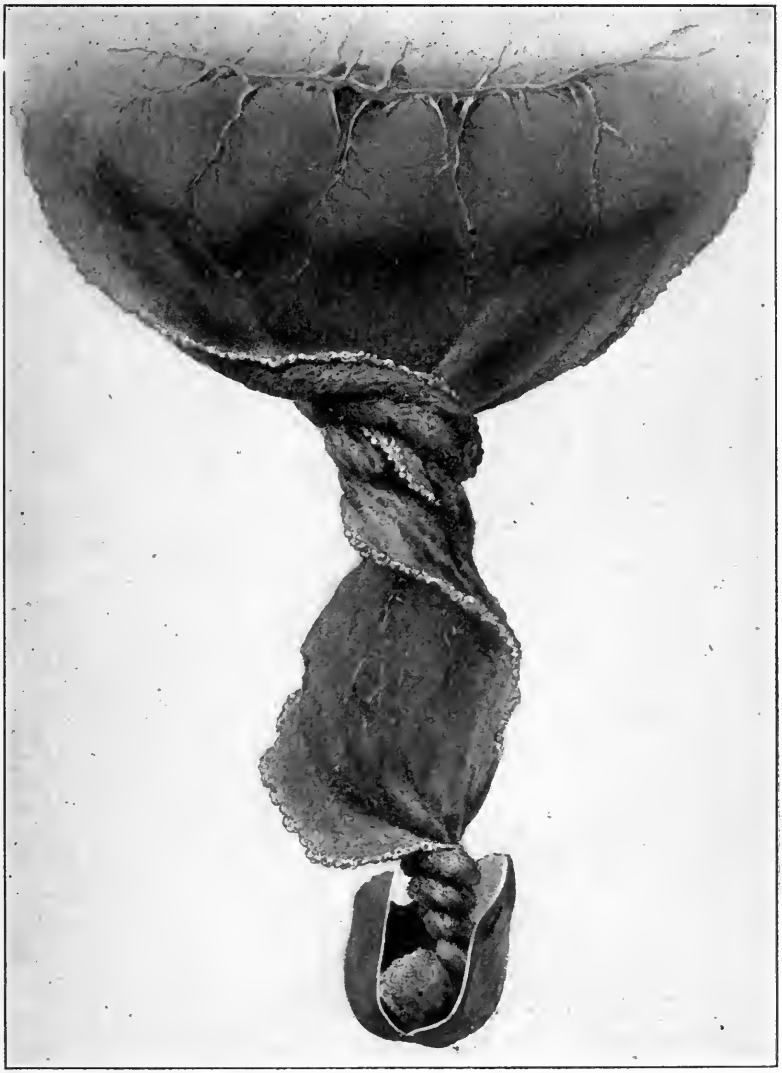


FIG. 311.—Resected omentovolvulus. Twist extended upward and ultimately caused acute occlusions. Note old inflammatory bands.

When omentovolvulus, or torsion, takes place acutely without association with hernia, the overt symptoms resemble those of acute appendicitis. Such attacks often develop as complications of inflammatory disorders and neoplasms of the omentum.

Fig. 311, made immediately from the specimen by my colleague,

Dr. S. M. Gellert, illustrates a case which I observed in St. Vincent's Hospital, in 1907. The man suffered from an oblique inguinal hernia for many years and wore a truss constantly. Acute symptoms set in which called for radical operation. They were suggestive of strangulation rather than obstruction and there were no signs of intestinal occlusion. Section revealed a tightly twisted omentum in the hernial sac the spiral extending upward into the abdomen blocking the circulation completely. The voluminous omentum, although completely thrombosed was not gangrenous and was removed successfully at its junction with the transverse colon. The man still lives and has had perfect health.

Causes of Torsion.—The peristaltic movement of the intestines doubtless imparts to the omentum not only the tendency to twist but also its direction. An elongated, redundant omentum predisposes to torsion just as it predisposes to hernia. Its matting or inflammatory thickening from any cause favors the tendency to torsion. Once a free end of the omentum becomes adherent, torsion is favored with two points of twisting. Newgrowths of the omentum, also, especially those which hang from its fimbriated ends, or edges, predispose to twist.

Hernia of all varieties is the most constant etiological factor. In proof of this Hedley reported 93 cases, of which details were obtained in 73, and out of this number 60 were associated with hernia, in 48 of which the twisted omentum was actually found in the hernial sac.

Diagnosis.—The diagnosis of omental torsion, whether of the acute or the chronic form, is very difficult. It can only be made by careful study of the history and painstaking physical examination. It should be suspected in the presence of an irreducible epiplocele, or omental hernia. Careful examination reveals an omental tumor more frequently on the right side which, unlike the tumor of a diseased appendix may be grasped by the hand and moved from side to side, and a fan-shaped, doughy mass may be traced upward to its base which rests against the transverse colon. There is no rigidity and the mass will be found surrounded on all sides by a resonant area. There is no tension in the sac, no sign of gas or liquid content, and no evidence of strangulated hernia. In severe cases when the torsion is acute, vomiting is present but there are no signs of acute intestinal obstruction, the lumen of the intestine being preserved. In the parasaccular form, torsion often being acute, the initial symptoms are severe with pain referred to the sac and with signs impending of acute strangulation. In all cases the fever is very moderate, the toxic phenomena mild, and the peritoneal reactions very slight.

Treatment.—It is always surgical. Indeed, gangrene is always so much to be feared that operation is essential in all chronic cases associated with hernia and a radical operation should be done, the omentum untwisted, divested of any faults and replaced. If it is notably elongated, it should be shortened. The greatest care should be taken to prevent matting or clumping, and the formation of adhe-

sions. In acute cases with strangulation, delays are fraught with danger and the quickest steps should be taken which should begin with an attack on the hernia. The incision should be extended so as to explore and determine the condition of the omentum. The zone of obliterated circulation should be minutely defined and resection made well above it.

In paracolic forms, if the circulation be still intact, the omentum should be carefully untwisted, first within the sac, and then above it within the abdomen. If there be manifest tendencies for the twist to recur, it should be prevented by the removal of redundant parts or, if need be, by the resection of the entire omentum. If in any case the omentum be found thrombosed throughout, the entire viscus may be removed flush with its attachment to the colon. The technic laid down previously should be scrupulously followed.

SPECIAL SURGERY OF THE GREAT OMENTUM.

Omentopexy, Epiplopexy, the Talma Operation.—This operation was first proposed by Talma, of Utrecht, in 1889, for the symptomatic relief of ascites in cirrhosis of the liver. Drs. Drummond and Morrison of Newcastle-on-Tyne quite independently reported, in 1896, a case of ascites due to cirrhosis of the liver cured by operation. The surgical intent in this operation is to cause a short circuit between the portal and the systemic circulation and the relief of the *impasse* which causes the transudation of fluid very largely from the omentum into the peritoneal space (ascites). The operation, although attended by a large mortality, is approved by many surgeons as a means of relieving the most distressing symptom of an incurable disorder.

The operation of choice still follows closely the lines originally proposed by Talma. The following technic is advised: An incision is made through the abdominal wall four inches in length beginning at a point one inch below the umbilicus. To one or the other side of the incision, six or eight inches of the omentum is brought down and a fold of it, from one to three inches in width, is stitched, by means of silk sutures, to the same width of peritoneal border. A broad area of adhesions is needed to make the requisite collateral circulation. This fusion of the tissues brings about an anastomosis between the radicals of the portal vein and those of the deep epigastric. The peritoneum is closed in the usual way and the wound sutured in layers.

Narath's modification of the Talma procedure deserves mention because of its safety and ease of execution. It brings the two sets of vessels into direct contact. Under local anesthesia, a short median incision is made above the umbilicus large enough to explore with the index finger and to deliver a strip of the omentum, three to six inches in length, which is anchored and carefully tucked by stitches between the fascial layer and the skin. The incision throughout is large enough to permit the passage of the omental strip and small enough

to prevent hernia. The abdominal incision is carefully closed in layers.

One of the great advantages of this operation is that it permits drainage of the peritoneal fluid into the connective tissue of the abdominal wall.

Surgery of the Cavity of the Great Omentum.—Tumors are now known to have their origin in the cavity of the great omentum. Eight cases have been reported by Ziembecki all of which were cancers.

Hernia.—Hernia of the abdominal contents, chiefly loops of the small intestine but also of other viscera, into the foramen of Winslow has been observed from time to time. Ziembecki has reported 20 cases prior to 1906 together with one case of hernia of the gall-bladder.

Fat Necrosis.—The entire cavity of the great omentum has been found involved in fat necrosis from pancreatic disease.

Cysts.—*Pancreatic Cysts.*—Pancreatic cysts have been known to invade the cavity of the great omentum, and also hydatid cysts.

Pseudocysts.—Encysted fluid (peritoneal) has been observed in the cavity of the great omentum in connection with local or general forms of peritonitis.

Pseudocysts (Sanguineous).—Encysted blood has been observed in the cavity of the great omentum as the result of severe abdominal injuries involving the spleen, pancreas, and the great vessels.

Abscess.—The cavity of the great omentum has been found to be the seat of abscesses springing from the liver and also from the perforation of ulcers of the duodenum and caries of the vertebræ.

THE SURGERY OF ILEUS.

By FRED T. MURPHY, M.D.

There is scarcely a medical writer of note who has not recorded his observations and opinions regarding the conditions which cause a cessation of the rhythmical advance of the content of the intestinal tract and the resulting symptoms. The literature of the subject is exhaustive,[1] so limitless that any attempt to abstract it can lead only to confusion. The very multiplicity of the varying opinions has tended both to obscure the relatively simple pathological change found in mechanical obstruction, and also to add to the difficulties of grouping satisfactorily the abnormal conditions which lead to an acute retention of the content of the intestine.

Certain authorities[2] have felt that the use of the term "ileus," even though modified by such adjectives as "dynamic," "adynamic," and "mechanical" has added to this confusion. From its derivation, ileus means to roll, to twist. In the minds of the early writers, an ileus was a rolling up or a twisting of the intestine, and therefore became synonymous with grievous colic. As representing the syndrome of symptoms accompanying the acute retention of the bowel content the term "ileus" is comprehensive, and it will be used in that sense. But the terms "intestinal paralysis" and "intestinal obstruction" define more clearly the reasons for the acute retention and to emphasize the underlying pathological conditions. These terms will, therefore, be used in this discussion.

In order that no confusion may arise in the use of certain terms, they are defined. By "occlusion" or "obstruction" of the intestine is meant the primary interference with the onward peristaltic action of the intestine independent of any primary circulatory change. By "strangulation" of the intestine is meant the interference with the normal peristaltic action associated with the change from the normal circulation of the gut. In the later consideration of this matter of circulatory disturbance it will be seen that simple occlusion or obstruction may change to an actual condition of strangulation independent of pressure upon or torsion of the mesenteric vessels. This possibility should be emphasized, for it explains many of the clinical symptoms which are otherwise difficult to interpret.

This chapter will deal with those conditions producing an actual obstruction of the bowel: (1) By mechanical interference; (2) by tonic contraction of the muscles of the wall; and (3) those acute

[1] Wilms: Der Ileus. Treves: Intestinal Obstruction.
[2] Nothnagel: Diseases of the Intestines and Peritoneum.

conditions, except peritonitis (to be discussed in another section) which cause a paralysis of the intestine leading to the development of the cardinal symptoms of acute stoppage. The spastic and atonic conditions of the large intestine underlying obstinate constipation will not be considered here. They are essentially diseases for medical treatment. Idiopathic dilatation of the colon, or Hirschsprung's disease, may be associated with an intractable paralysis of the large bowel, but it is so distinct both in its pathology and symptomatology from the conditions which are characterized by the symptom-complex defined by ileus that it will also be omitted from this discussion.

The cases in which there is a mechanical obstruction of the intestine are those amenable to and demanding early surgical interference. This group is, therefore, considered first and in greater detail, though it includes only about 28 per cent.[1] of all cases of ileus.

Causes of Mechanical Obstruction.—The causes of mechanical obstruction of the intestine may be irreducible hernias, either internal or external, new growths involving the gut, constricting bands acquired or congenital, invagination of the intestine within itself, intussusception, volvulus, cicatricial strictures, pressure upon the intestinal lumen from intra-abdominal tumors, congenital defects, and foreign bodies within the lumen. Extensive circulatory disturbances such as a mesenteric thrombosis may cause, to all intents and purposes, a mechanical obstruction, though actually this obstruction is due to a paralysis of the thrombosed segment, and it should be so classified.

It is difficult to establish trustworthy percentages as to the relative frequency of the various causes of mechanical intestinal obstruction, because of the wide variation which is to be found in the character of the material admitted to hospitals of different types. In the experience of every one, however, the obstruction is caused most frequently by irreducible hernias, constricting bands and new growths involving the wall of the intestine. When we consider the almost innumerable anatomical anomalies in the form of peritoneal fossæ, defects, such as slits in the mesentery, and the large number of possible external herniæ, it is readily seen why this type of obstruction is more common than the others. To enumerate and describe in detail each anatomical possibility is a futile task. In considering obstruction from herniæ, we need only to remember that a loop of intestine may be caught in any one of these congenital or pathological pouches and obstructed and possibly strangulated. Because of the relatively fixed position of the large intestine, it is infrequently found obstructed in herniæ, but, excepting the stomach, it is the most common site of new growth in man; hence the high percentage of occlusions from this cause to be found there. In the small intestine, on the contrary, cancer is of such rarity that it may be disregarded as a cause of obstruction, Venot and Parcelier[2] having been able to collect only 50 cases to 1913.

[1] Murphy, J. B.: Kelly and Noble's Abdominal Surgery, vol. ii.
[2] Revue de Chir., 1913, xlviii, 436.

The constricting bands may be the result of a previous inflammatory process or the result of adhesions caused by an operation. The congenital bands are most typically represented by the persistent

FIG. 312.—Meckel's diverticulum. (Museum, Washington University Medical School.)

Meckel's diverticulum. Whatever be the cause of the bands, the mechanics of the obstruction are the same. For some reason, the band, as the string upon the bow, draws taut across the intestine and the obstruction once started is further increased by the force of the

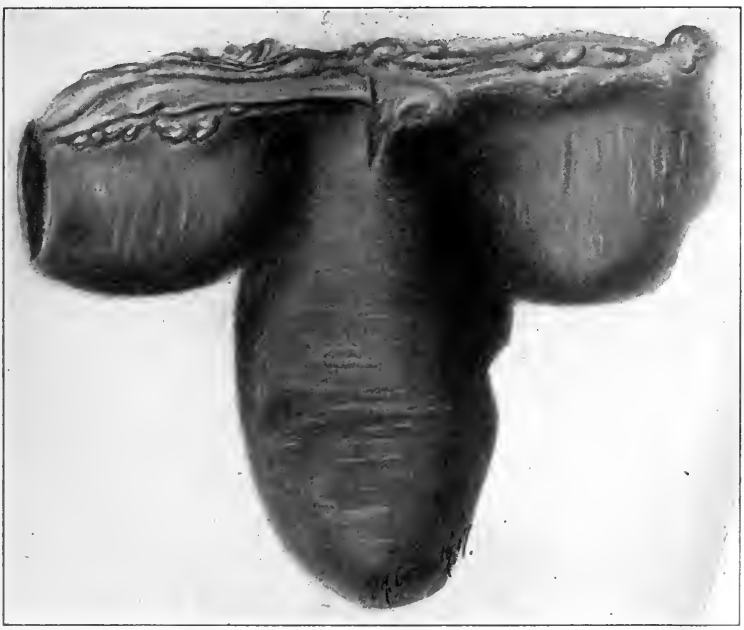


FIG. 313.—Meckel's diverticulum. (Museum, Washington University Medical School.)

intestinal contraction. Adhesions of the intestines *en masse* may result in obstruction, but they are not so apt to cause trouble as adhesions of the string type formed by the mesentery or by single bands

between loops of intestine or extending to the parietal peritoneum or other organs.

Intussusception is the common form of obstruction in young children, but after the first two years of life, the percentage of cases falls rapidly, and after the second decade it is a relatively uncommon lesion. Four anatomical types are recognized: The ileocecal, the enteric, the colic and the ileocolic. The most common of these is the invagination of the ileum into the cecum with the ileocecal valve, that is the ileocecal. This form is to be distinguished from the rare ileocolic type in which the ileum prolapses through the ileocecal valve. A polyp may be the cause of the beginning of the invagination as

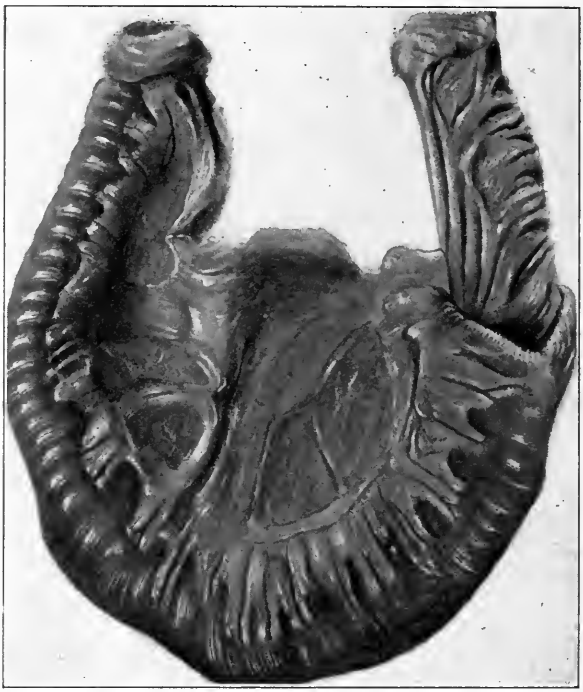


FIG. 314.—Intussusception, enteric type, experimental lesion.

may a Meckel's diverticulum, but in the majority of cases no primary factor can be demonstrated for the pathological contractions by which the intestine prolapses into itself and endeavors to expel the intussusceptum as if it were free intestinal content.

The mechanism by which a part of the intestine is invaginated into the lumen of the bowel adjacent to it is definite. In all except the ileocolic variety, the apex of the intussusceptum, that is the invaginated gut, remains unchanged, and the increase in the length of the intussusception is at the expense of the outer layer or intussuscipiens. With the ileocolic variety, an actual prolapse of the lumen takes place as long as the small intestine can descend into

the colon, and then the further formation of the intussusception is by the same method as in the other forms. These acute intussusceptions are to be sharply differentiated from those which occur in the

FIG. 315.—Intussusception, ileocecal type. (Museum, Washington University Medical School.)

moribund. The latter are usually multiple and frequently retrograde. The acute type are almost without exception single, and always form in the direction of the peristaltic waves. The rare

retrograde intussusceptions which have been described occur in the colon. They are the result of the reversed peristalsis which occurs normally in that part of the intestinal canal. As the intussusception advances, the pressure upon the mesentery is increased. Consequently the circulatory disturbances in all the bowel which is involved may be very rapid and extreme.

Volvulus is the special term used to designate an intestinal obstruction which is caused by a rotation of some part of the bowel upon its own mesentery or around another loop of intestine. The twisting of a loop of the gut upon its own mesenteric axis is the common type

FIG. 316.—Intussusception. (Museum, Washington University Medical School.)

and constitutes one of the frequent causes of obstruction. The intertwining of two loops of intestine so that they rotate about each other and cause an occlusion of the lumen, is the rare form of volvulus. In either type, the twisting of the loop of bowel which leads to the obstruction causes at the same time, by the torsion of the mesentery, serious circulatory disturbances in the portion of the intestine so rotated. The result of this mechanical process is to cause a simple obstruction of the intestine above the level of the twist and also strangulation of the rotated loop.

Volvulus is most commonly found in the sigmoid flexure because it lends itself most readily to a twist upon its own mesentery as well as around a loop of small intestine, both on account of the length of the mesentery and the character of the intestinal content. Next in frequency is the volvulus of the cecum. Here again, the length of the mesenteric attachment plays an important role, and there may be a twist of the small intestine upon itself. A failure of all or a part of the intestinal tube to become normally attached to the posterior abdominal wall increases the tendency to volvulus of any part.

Considering the number of ulcerative processes which are commonly found in the intestinal canal it is remarkable that the cicatricial stenoses are so rare. The acute processes such as typhoid, tuberculosis, and the severe ulcerative dysenteries rarely cause obstruction. Chronic processes found usually in the lower rectum are important

Fig. 317.—Carcinoma obstructing adjacent intestine by extension. (Museum, Washington University Medical School.)

factors; whether they be due to a mixed or specific infection, the result is the same—a gradual narrowing of the lumen until it is not possible for the fecal content to pass the stricture. A very considerable percentage of the patients with these cicatricial stenoses of the rectum give positive Wassermann reactions, but without doubt syphilis is only one of many factors in their etiology.

Any new growth may press upon and constrict the intestinal lumen. The more common are the uterine and ovarian tumors of the pelvis. Of the congenital defects, the one class of primary and particular importance is that in which there is a failure to establish the patency of the intestinal canal at the anorectal junction. The other congenital defects occurring in the small bowel are hardly to be considered within the possibility of surgical interference. The most usual sites are at the junction of the ileum with the cecum and in the region of the duodenum.

Of the foreign bodies causing obstruction a typical example is that associated with the passage of a large gall-stone which has ulcerated from the gall-bladder into the intestinal lumen. The spasm of the intestinal wall around the stone may cause the obstruction rather than the stone itself. Such cases are to be considered as surgical curiosities, as is obstruction from fecal impaction requiring surgical intervention. Other foreign bodies may cause obstruction, but fortunately anything which will pass from the stomach will usually be carried through the intestinal canal.

As the obstruction resulting from any of these possibilities causes a sudden, complete occlusion of the lumen with or without strangulation or a progressively advancing or intermittent, partial obstruction, we have the acute or chronic types of mechanical intestinal obstruction.

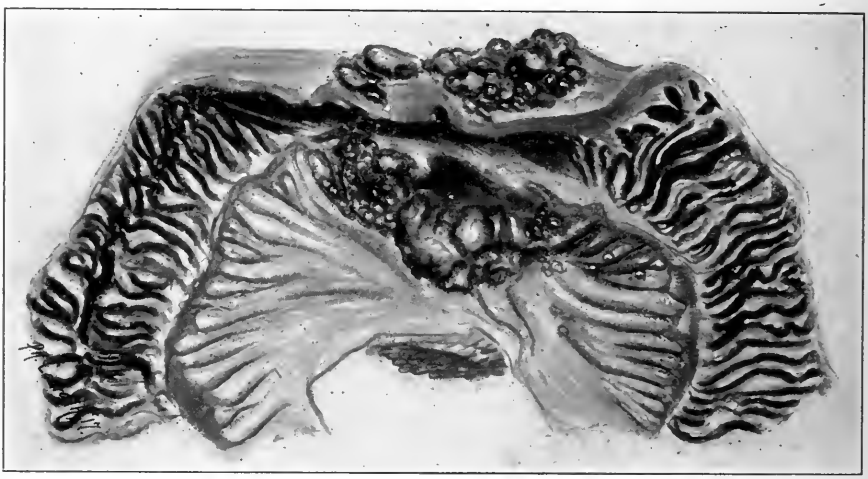


FIG. 318.—Small intestine obstructed by metastatic cancer. (Museum, Washington University Medical School.)

Pathology.—Nothing is more confusing to the inexperienced observer than to try to reconcile the symptoms of a series of patients who have suffered from acute intestinal obstruction. He finds that in the one case there was the typical picture; in another, of apparently the same mechanical conditions, an entirely different clinical picture; and in a third, still another. If we consider first the pathological changes which occur in intestinal obstruction, and then the symptomatology, the clinical picture, I think, will be much clearer. Certain physiological facts are first to be noted and emphasized. The parietal peritoneum is sensitive; the visceral peritoneum is insensitive. Save for the pull upon the mesentery, the intestine may be cut or burned without causing the slightest discomfort to the patient. Abdominal pain due to the intestine is the result of abnormally violent contractions of the intestinal wall, tension upon the mesentery, or

involvement of the parietal peritoneum by a secondary inflammatory process. Vomiting is either reflex or regurgitant; that is, the stomach contracts either from the stimulus of nervous impulse, or, when overdistended, empties itself by letting the content seek the outlet of least resistance. Except in the large bowel, the rhythmical peristaltic action of the intestine propels the content toward the rectal outlet. In the proximal part of the large bowel, as demonstrated by Cannon,[1] there is a normal reversed peristalsis, and it has been shown by many observers that under certain conditions, this reversed peristalsis may carry the intestinal content for a considerable distance above the ileocecal valve. Nothnagel accepts the theory of a reversed peristalsis in the small intestine, basing his conclusions upon the experiments of Muhsam, Enderlen and Hess. The work of Mall,[2] however, seems to refute absolutely this opinion. Without doubt, a section of the intestine may be reversed and there may follow normal evacuations of the bowel, but it will be found on examining this reversed loop of intestine at a considerable time after the reversal that it takes no part in propelling the intestinal content. It acts simply as a tube, the content being pushed over this inert or possibly for a time actively obstructing segment by the force of the peristalsis in the normal intestine. In the laboratory we have repeatedly reversed loops of intestine in animals and have found without exception that later they came to be dilated segments without peristaltic activity. The question of the possibility of a reversed peristalsis has a most important bearing upon the symptom of vomiting and its diagnostic significance. Vomiting in intestinal obstruction represents, then, either a reflex contraction of the stomach, or a running over of the stomach due to the escape of the intestinal content back through the relaxed pylorus. With violent peristaltic waves pushing the intestinal content against an obstruction, there is a recoil as demonstrated by Cannon and Murphy[3] in their experimental work on certain phases of intestinal obstruction, but not a true reversed peristalsis. While clinical reports of cases of unquestioned fecal vomiting are not to be discredited, they must be accepted *sub judice*. As an example of the errors in observation which may occur, the following case is cited: This patient had been operated upon several times; first for an appendicitis, later for a resection of a carcinoma of the hepatic flexure. At this operation, the upper part of the ascending colon and a part of the transverse colon had been removed. The ileum had been joined to the remaining part of the transverse colon by a lateral anastomosis. This left a blind pouch formed by the cecum and a part of the ascending colon. Shortly after the operation, the patient experienced much pain and a tumor mass was felt in the right lower quadrant. This later disappeared. On account of the presence of the mass, a later

[1] Am. Jour. Physiol., 1902, No. 5, vol. vi.
[2] Johns Hopkins Hosp. Reports, vol. i, p. 93.
[3] Ann. Surg., April, 1906, No. 4, vol. xliii.

exploration was decided upon. The operator found the cecum contracted, bound down by adhesions, and apparently causing no trouble, so it was not removed. In the succeeding years, this patient had periods of apparent relief, followed by periods of discomfort, at which time he would vomit frank fecal material. There was a marked neurosis and the consensus of opinion was that we had to deal here with a true reversal of peristalsis. At the autopsy, however, it was found that the upper end of the blind pouch of the ascending colon connected with the stomach by a fistulous tract. The mechanism of

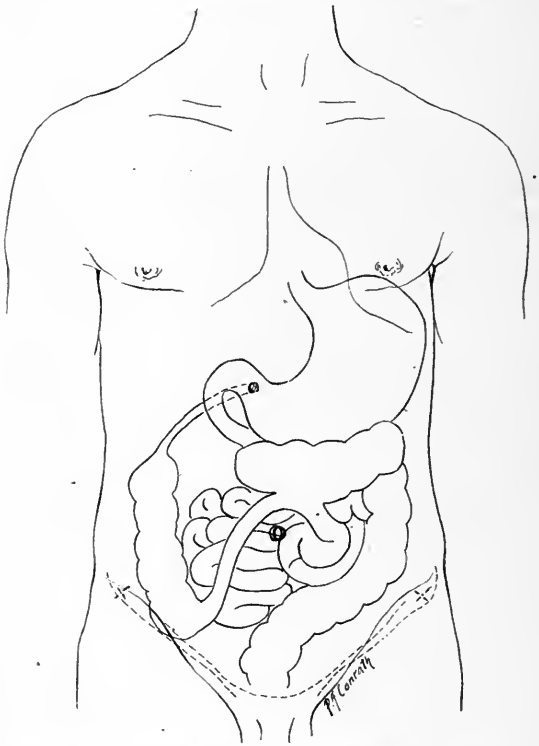


FIG. 319.—Drawing illustrating the condition found at autopsy in the patient with fecal vomiting.

the vomiting of the fecal material was thereby readily explained. At times the fecal stream passed from the ileum into the transverse colon. At other times, this lateral anastomosis failed to divert the content, the cecum became filled, and the large bowel content was expressed into the stomach. Without an autopsy, this would have been recorded as a case of true fecal vomiting.

The duodenum and upper jejunum are relatively sterile as compared with the lower ileum and the large bowel, but in this first portion of the small intestine there are bacteria, and with an obstruction of

this segment they multiply rapidly. The secretions of the upper part of the small intestine are abundant, and they persist for an indefinite period after the physiological activity of the intestine has been withdrawn. The secretions of the ileum are comparatively small in amount and they do not continue for any considerable time after there is no longer a functional demand.

Under normal conditions, the rhythmical peristalsis of the intestine cannot be followed through the abdominal wall, except where the wall is very thin, and then the normal peristaltic action may be plainly evident. In a chronic condition where there has occurred a hypertrophy of the intestinal wall from the effort to overcome the partial occlusion, this visible peristalsis is marked. In an acute condition, on the other hand, the hyperactivity may be marked, but a paralysis of the intestinal wall may result from this overstimulation and lead to a paralysis.

Inability to make up for the body fluids which are lost through excessive vomiting leads to a rapid dehydration of the whole body, accompanied by a more or less complete suppression of urine. McQuarrie and Whipple[1] have shown experimentally that animals with obstructed loops of intestine or animals which had intravenous administration of the toxic contents of obstructed loops of gut show a marked diminution in the renal function and a corresponding high non-protein nitrogen retention in the blood. This is believed to be a direct effect of the toxin on the renal epithelium. Gas is normally produced within the intestinal lumen, and with a normal metabolism a proper balance is maintained within the intestine. Either a pathological increase of gas due to putrefactive changes or a pathological decrease in its absorption leads to a marked local accumulation.

The pathological changes causing acute symptoms due to absorption of the toxic bowel content, which occur in an obstructed loop of intestine depend either upon the pressure within the lumen or upon direct interference with the circulation by pressure on the veins or arteries supplying this segment. Pressure upon the bloodvessels, that is strangulation of the mesentery, has been recognized generally as the important factor in the production of these toxic symptoms. Pressure within the lumen of the gut has not, it seems to me, been sufficiently emphasized. The pressure within the intestine may lead to exactly the same pathological change so far as the production of the symptoms is concerned, as actual pressure upon the mesentery. This abnormal pressure within the intestine depends upon the amount of material within the obstructed portion of the gut, be it fluid or gas, plus the tension of the muscle wall. As this pressure increases, there occurs first the venous stasis in the small vessels of the intestinal wall. This is followed first by an edema of the mucosa, and later by its destruction. With the mucosa destroyed, there no longer exists

[1] Jour. Exp. Med., 1919, xxix, 397.

the protective filter of the normal mucous membrane, and the absorption of any toxic substance from the intestinal lumen is rapid. The possible rapidity and amount of this absorption is difficult to appreciate. Given a septic focus in the hand and a virulent organism, and all realize how fulminating may be the ascending lymphangitis. The absorption from such a focus must be, however, infinitesimal as compared with the absorption from the intestine when the normal protective mechanism has been destroyed. The same series of changes occur in the intestinal mucosa when the circulatory disturbance is secondary to direct interference with the blood supply by strangulation of the mesentery. Appreciation of the importance of this pressure within the lumen of the intestine combined with that of the circulatory change will explain in great measure the variations seen between obstructions high and obstructions low, obstructions with and without strangulation. As has been stated, the secretions of the upper small bowel are rapid and persistent. In simple high obstructions, then, there follows a relatively rapid distention of the intestine, which leads to an early circulatory disturbance. With simple obstruction of the lower bowel, the degree of distention is relatively slight, and the onset of the circulatory change is late. Therefore, comparing a high obstruction with a low obstruction, we may have the widest variations in the time of the onset of acute symptoms of absorption. Obstruction of the large intestine provides a still larger reservoir and the distention leading to symptoms from absorption of the toxic content is still further delayed. These circulatory changes can be demonstrated definitely only in experimental work, since in clinical cases the operator can never be sure of the exact time nor the exact degree of venous or arterial pressure which has existed. The circulatory changes which occur in cases of volvulus or strangulation may be of any degree.

In a series of experiments, Murphy and Vincent[1] demonstrated that obstructions of the venous return from a closed loop of intestine caused the most severe and most rapidly appearing symptoms. The change in the mucous membrane in the intestine with an obstruction to the venous return showed marked distention and destruction of the mucous coat within four hours and explained the rapidity of the absorption because the content was under pressure and the portals of absorption widely open. They demonstrated also that a complete anemia of the intestine led to the production of the same symptoms, but that these were less rapid in their onset.

The observations of Hartwell and Hoguet[2] showed most graphically how small a part simple obstruction plays provided there is no destruction of the mucous membrane. In their experiments the small bowel was obstructed 10 to 30 cm. from the pylorus by a clamp

[1] Boston Med. and Surg. Jour., 1911, No. 18, clxv, 684.
[2] Am. Jour. Med. Sc., 1912, cxliii, 357.

PLATE XV

To Show the Striking Effect of Complete Venous Stasis of Four Hours.

so applied as not to injure the mucous membrane. With an obstruction so high, the content of the obstructed intestine overflowed rapidly into the stomach through the relaxed pylorus, from which it was expelled by vomiting or removed by lavage. Therefore no distention of the intestine was caused which might lead to circulatory change from the increase of tension. Under such conditions they were able, by supplying water to their animals subcutaneously, to keep them alive for ten days.

The adherents to the so-called reflex nervous theory as a cause of death in intestinal obstruction have been impressed by the suddenness and the intensity of symptoms which, in the fulminating cases, seem to be of such a character that they must be of nervous origin. Experimentally, however, no direct proof in support of this theory has been produced. On the contrary, the connection with the central nervous system may be severed, and yet the production and degree of symptoms remains unchanged.

The more recent and active investigators of this subject are agreed that death in cases of acute mechanical obstruction without perforation, is caused by the absorption of some toxic substance from the lumen of the gut. As to the exact nature of this substance and the essentials for its production, differences of opinion exist. Whipple[1] and his co-workers at Baltimore and at the University of California, believe that this toxic substance is primarily a perverted secretion of the intestinal mucosa. Murphy, Vincent and Brooks, on the other hand, believe that this toxic substance is the result of bacterial action upon the content of the intestine. Whipple[2] has recently isolated a proteose which he considers to be the substance especially concerned in the intoxication in these cases of intestinal obstruction. Other experimenters[3] have believed that the toxic substance was some one of the various ptomaines. From a practical standpoint, the pathological changes are important as they have a direct bearing on the production of symptoms and upon the treatment of the condition. If it is agreed that the toxic substance has been produced in the intestinal lumen, then the changes which permit of the absorption of this toxin are crucial. Kocher,[4] years ago, called attention to the small ulceration which may be found in the mucosa of an obstructed intestine. The belief of that time was that death was caused in these cases through the passage of bacteria through the wall of the gut, causing thereby a peritonitis, the absorption from the peritoneal cavity playing a part no less important than the absorption from the lumen of the intestine. This contention has been disproved by experimental work, because it is possible to cause death by intestinal obstruction and to have the fluid within the abdominal cavity both

[1] Bull. Johns Hopkins Hosp., 1912, xxiii, 159; Ann. Surg., lix, 714.
[2] Jour. Am. Med. Assn., No. 1, lxvii, 15.
[3] Von Albeck: Arch. f. klin. Chir., 1901, lxv, 569.
[4] Mitt. a. d. Grenzgb. d. Med. u. Chir., 1899, iv, 201.

free from bacteria and harmless on injection. These ulcers are important in that they represent breaks in the mucous membrane and openings for the absorption of the toxic content. They are secondary to circulatory changes, not primarily the result of pressure except as this pressure causes an anemia. That this toxic material is not a specific secretion of any part of the intestinal tract as has been maintained by some has been demonstrated experimentally by Murphy and Brooks.[1] That it is dependent upon the action of bacteria combined with the degenerative changes in the mucus-lined cavities seems equally clear from their work. They were able, after prolonged drainage, to secure a loop of intestine, which was closed at one end and opening through the abdominal wall at the other, in which there were no bacteria. They obstructed this loop. After a period of time at which, under the usual conditions of the intestinal content, there should have been formed a toxic substance, this content was removed though the experimental animal had shown no symptoms of toxic absorption. On injection this content was found to be non-toxic. The same loop of intestine was again obstructed after it had been infected and the content later was proved to be toxic both by the symptoms of absorption in the host and also by injection of the content into other animals.

The experiments of Dradstedt, Moorhead, and Burcky[2] bear directly on this question as to whether the bacteria had or had not played an important role in the formation of the toxic substance found in the lumen of the gut in cases of intestinal obstruction. They confirmed the results of other investigators as to the fatal results of immediate closure of a duodenal or jejunal loop, the animals dying in forty-eight to ninety-six hours. After washing the segment of the jejunum, however, with either sterile water or salt solution they were able to close both ends of the intestine and to have a considerable number of these animals live indefinitely. They found that when isolated, closed loops of the jejunum were sterile, complete occlusion of the bloodvessels had no effect on the animal, but if the loops were not sterile the occlusion of the circulation caused death in twenty-four to forty-eight hours, with the usual symptoms of complete intestinal obstruction. In other experiments they placed open loops of the duodenum, sectioned just below the inferior pancreatic duct, in the abdominal cavity. In 50 per cent. of these experiments the animals lived without symptoms, and later the ends of the intestinal loops were found completely closed by adhesions and the lumen seemed distended with a sterile fluid. These experiments confirmed the opinion that the normal secretions of the duodenum and jejunum are not toxic and that bacterial activity plus necrotic tissue or the results of the action of the bacteria on the necrotic tissue is an essential factor in producing symptoms in intestinal obstruction.

[1] Arch. Int. Med., vol. xv, p. 392.
[2] Proc. Soc. Exp. Biol. and Med., No. 1, xiv, 17.

Since these sterile intestinal loops were produced only after the greatest difficulty, gall-bladders were used as receptacles by Murphy and Brooks.[1] If the circulation of a sterile gall-bladder were altered and the cystic duct obstructed the content remained non-toxic to injection even though the gall-bladder had begun to be gangrenous. If, on the contrary, these same changes were brought about and the content of the gall-bladder infected then this content at the end of two days had the same toxicity and produced the same symptoms and pathological changes which were found upon the injection of the toxic content of obstructed loops of intestine. Chemically it was not proved that this toxin was identical with that found in the obstructed intestine.

These pathological changes emphasize the importance clinically of a circulatory change in the obstructed intestine, since by that circulatory change the normal filter of the mucous membrane is destroyed. With the mucous membrane intact there is no absorption from the intestine of this virulent toxin found in the obstructed intestine. This can be shown by confining the toxic material within an occluded loop of intestine in which no changes have occurred in the mucosa. Under such conditions the experimental animal continues without clinical symptoms of absorption. This fact has been even further substantiated by the experiments of Brooks,[2] who showed that if a long segment of jejunum and ileum were isolated and occluded at both ends that distention of such loop very gradually developed, and the animal showed only slight symptoms of absorption of the toxic loop content at the end of twenty-one days, in spite of the fact that the occluded loop of gut contained as much as two hundred times the lethal dose of the toxin. That the content of an obstructed bowel may be extremely toxic and still not produce symptoms of rapid absorption is well illustrated by the following case:

R. E., white, female, aged nineteen years, nurse, S. N. 3021. Operated on May 21, 1916, for subacute appendicitis. Surrounding the appendix numerous old adhesions were found, which increased the difficulties of the operation. Postoperative convalescence for first forty-eight hours was uneventful. At this time the temperature was normal and the pulse ranged from 98 to 115. The patient then began to have an unusual amount of abdominal pain. Vomiting continued even though nothing was given by mouth, and the stomach was lavaged. On the seventh day following operation the temperature was normal and the pulse slightly over 100. There was no distention. Enemata were followed by bowel discharges, which were considered fecal. The urine had decreased to about 300 c.c. in amount and contained acetone, but was without albumin or casts. The blood count ranged from 20,000 to 35,000. The abdomen was not distended. There was an unusually violent attack of vomiting, and

[1] Arch. Int. Med., vol. xv, p. 392.
[2] Ann. Surg., 1918, lxvii, 210.

serum was expressed from the abdominal wound at this time, which seemed to confirm the opinion that the continued vomiting and abdominal pain might be due to absorption from some local infection. The abdominal pain later, however, continued to occur in such sharp paroxysms and so rhythmically that exploration was decided upon. At operation a considerable amount of free fluid was found in the abdominal cavity. About two feet from the ileocecal valve the intestine was found to be sharply occluded by adhesions. Above this level the gut was markedly distended and below was collapsed. The distention was so great that it was possible to complete the operation without trauma to the intestine only after withdrawal of a considerable amount of the content above the obstruction. The adhesions were separated and the raw surface covered with peritoneum. Following the operation the patient made an uninterrupted recovery. Fluid obtained from the intestine at the end of operation was injected into animals. It was found to be virulently toxic.

There can be no doubt that this patient suffered for several days from obstruction of the ileum. The content was proved to be very toxic. The distention had not been sufficient to destroy the mucous membrane and the absorption had been practically *nil*. After relief of the obstruction the toxic content passed into the normal intestine, but caused no symptoms.

Symptoms.—Confused as may have been the ideas as to the etiology, pathology and treatment the essential clinical symptoms of intestinal obstruction have been recognized and emphasized since the earliest days of the practice of the art of surgery. These essentials are pain, nausea and vomiting, distention and collapse. The absence of visible peristalsis, the presence or absence of fecal movements, the variations in the temperature, pulse and blood count and the changes in the urine are of secondary importance. The typical case of acute mechanical obstruction may show all of the essential as well as the less important signs and symptoms. The correct diagnosis of the atypical case has been the interesting problem which modern surgery has tried to solve. As was stated earlier in this section the chronic cases have a symptomatology quite distinct from the acute. In fact, until the chronic case becomes acute the symptomatology is not characteristic. The pain and the difficulty in moving the bowels may be simulated by an extreme constipation. Provided the obstruction is so low in the rectum that the fecal mass has not time to reform before it is evacuated, then we have the typical misshapen stool; but the importance of this as an aid to diagnosis has been much overestimated. Increasing difficulty in moving the bowels with recurring attacks of colic are suggestive of a chronic obstruction of some degree. The history of attacks of constipation followed by diarrhea or the passage of stools mixed with mucus and blood suggests some mechanical obstruction. Ultimately these chronic cases may become acute. Since the majority of chronic obstructions occur, however, in the large bowel the onset

of even the acute symptoms may be delayed for a considerable period after there is a complete mechanical obstruction.

In striking contrast to this indeterminate symptomatology of chronic intestinal obstruction is the clear-cut symptom-complex found in the acute cases. The onset is sudden, with colicky pain and nausea or vomiting. The pain is due to the hyperactivity of the intestine in its endeavor to overcome the obstruction. The rhythmical recurrence of the pain is coincident with the contraction and the intervals of relief represent the periods at which the intestine is at rest. (The demonstration of visible peristalsis under these conditions is pathognomonic of intestinal obstruction. The failure to demonstrate it has relatively little diagnostic value.) With the resulting paralysis of exhaustion there may occur a relief which is most misleading. In the early stages the contractions of the intestine are evidenced by the presence of visible peristalsis, unless there is an extremely thick abdominal wall. Later, as the intestine may become exhausted, this visible peristalsis may no longer be evident.

The vomiting is at first reflex and later, as has been explained, is the result of a running over of the intestinal content into the stomach. The term "fecal vomiting" is often used in connection with intestinal obstruction. As the vomitus may represent intestinal content it is rightly so considered, but I question very much whether formed particles of feces have ever been returned from the intestine to the stomach save by pathological fistulæ.

The collapse varies in degree, depending upon the amount of absorption, this absorption depending in its rapidity upon the character and location of the obstruction. With a high obstruction the absorption is rapid; with a low obstruction, slow. With the strangulation of the intestine at whatever level it is rapid. This is so because, as has been stated, with the strangulation the circulatory change leads to an early destruction of the protective power of the mucous membrane, as is the case also with the rapid distention of the jejunum on account of the very abundant secretions. Save for acute pancreatitis there is no other intra-abdominal condition which may cause such extreme collapse as acute intestinal obstruction. On the other hand, in contrast to the hippocratic facies with the sunken eyes, with the dark circles underneath them, and the anxious expression so difficult of description and yet so typical when seen, there may be a surprising absence of the collapse. This is illustrated by the following case history:

L. R., aged thirty-five years, negro, male, S. N. 496. Eight days before entrance the patient had normal bowel movements. Two days later he noticed that the trousers band was tighter than usual and he had considerable abdominal pain. For five days before entrance had had cramping pains in the abdomen, but had not vomited. At entrance the pulse was 70, temperature 99°, white blood cells 20,000. Examination of the abdomen showed the liver dulness to be completely obliterated and shifting dulness could be demonstrated in the

right flank. The distention was symmetrical and general. Urine negative. At operation a distended loop of large intestine was found the loop being constricted by a single, dense adhesion. To expedite the exploration the content of the loop was removed by trocar. Patient's condition became suddenly alarming, and before the abdomen could be closed he died.

The patient entered the hospital with a normal temperature and with a pulse of normal rate. The history of obstruction for at least five days seems very definite. The sudden collapse after the short operation with a minimum amount of trauma showed that the absorption had been great, but was not evidenced by the clinical condition.

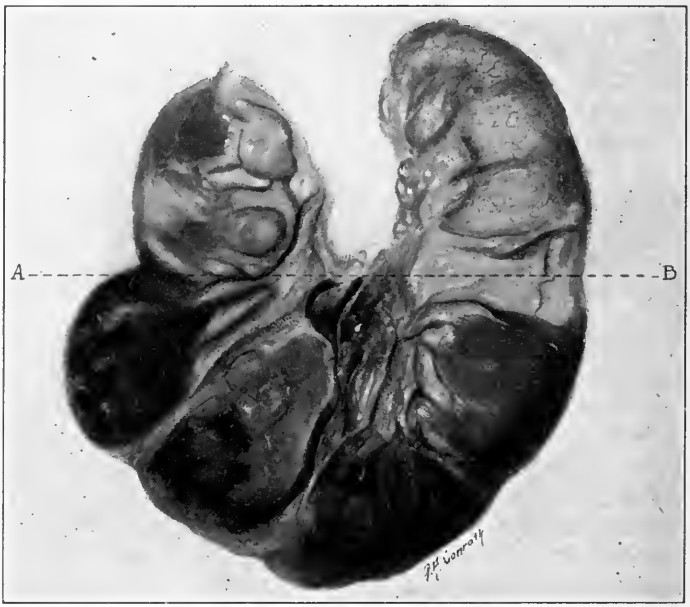


FIG. 320.—Gangrenous bowel from strangulated hernia. Line *A....B* shows level of strangulation.

The accumulation of gas, that is, the meteorism, may or may not be a pronounced symptom. This also depends upon the location and character of the obstruction. Given a simple obstruction high, but little distention is possible except by the dilatation of the stomach, and today lavage of the stomach is so nearly a routine treatment of nausea that this condition will be rarely observed except in neglected cases. Given a simple low obstruction, there will follow ultimately the distention of the greater part of the gastro-intestinal tract. Given a volvulus the primary and marked meteorism will be limited to the region of the strangulated loop. Nothnagel in his comprehensive

Encyclopedia emphasizes the importance of the definite location of meteorism in the diagnosis of mechanical obstructions.

Interesting as is the speculation as to the site of the obstruction, as evidenced by local meteorism, and positive as the findings may be in certain cases, yet this may be masked in so many ways that practically it is a refinement in diagnosis which in the acute cases is unessential and in the chronic cases may be demonstrated more exactly by the *x*-ray examination of the intestinal tract after a bismuth meal or enema.

As to the degree, collapse varies, and for the same reason varies the rate and the character of the pulse. As an index of the condition of the patient the pulse, considering the rate as well as the character, is more reliable than is any other single symptom. The rate is usually increased, and as the absorption becomes profound the quality becomes correspondingly poorer. The thready, barely perceptible pulse, with the cyanotic, cold extremities, both unmistakable evidence of the terminal collapse, are in striking contrast to the sense of euphoria. This sense of well-being and the active, unclouded mind in the last stages complete the typical ileus syndrome. An infection of the peritoneum may result at this time from an actual perforation of the obstructed intestine or from the permeation of the bacteria through the damaged wall of the gut. When this occurs the associated peritonitis masks the primary obstruction and intensifies all symptoms.

The blood-pressure follows, in general, the pulse change, showing the primary rise and later a fall.

The temperature is inconstant. In the extreme cases it may be subnormal, but, as a rule, it is slightly elevated. The white blood count usually is increased, but in fulminating cases and in the late stages of an obstruction there may be seen the same failure to react as may be found in a spreading peritonitis. To illustrate how meager may be the symptom-complex in intestinal obstruction I cite the following case:

C. T., white male, aged twenty-two years, S. N. 2897. Twelve hours before entrance to the hospital the patient had been seized with sudden abdominal pain and had vomited. The bowels were satisfactorily moved twice by enemata. The pains had been cramp-like; had occurred at intervals of about one-half hour for periods of five to ten minutes. Nine months previous to admission he had been operated on for appendicitis. At entrance the temperature and pulse were normal. The white blood cells, 9600. The abdomen was not distended. There was no visible peristalsis. Because of the recurring cramp-like pain and the history of a previous operation immediate exploration was decided upon. At operation the lumen of the ileum was found to be obstructed by a single band of adhesions just above the cecum. The intestine above this level was distended and below collapsed. The adhesion was cut and the bowel below immediately filled with the content from the obstructed intestine. Uneventful recovery.

The examination in this case was negative. From the history were obtained three facts of importance: The patient had been operated upon, he had been seized with severe abdominal pain which had recurred at intervals and he had vomited.

The urine becomes scanty, as might be expected with the extreme dehydration. It may contain certain chemicals, such as phenol and indican, but the presence or absence of these is rarely of importance, though indican theoretically should be found in occlusion of the small intestine and be absent in obstruction of the large.

Generally much stress is laid on the presence or absence of the passage of feces or gas. With an acute obstruction a complete paralysis of the intestinal movements may result below the level of the obstruction. In my opinion the information obtained as to the passage of feces or gas may be very misleading. Because they are returned from the large bowel after an enema does not signify there may not be an obstruction higher up. Not infrequently the proper treatment of cases which otherwise would have been correctly diagnosed has been delayed because of the emptying of the bowel below the level of the obstruction. The character of the fecal discharge may be all but pathognomonic of certain conditions causing ileus. They are intussusception, with the mucous or bloody mucous stool; progressive narrowing of the lumen in cancer, with the increasing constipation and blood-streaked movements alternating with diarrhea; the rice-water discharges of mesenteric thrombosis and the absence of lanugo hairs in the meconium of the newborn in congenital occlusion of the intestine.

Diagnosis.—Of first importance in considering the diagnosis of a suspected case of intestinal obstruction is the history. This should include the present acute attack and also a careful review of the patient's previous illnesses and condition. The statement that a hernia has existed in times past but is not now present may suggest either an obstruction from a reduction *en bloc* or from a constricting band. A previous laparotomy always suggests the possibility of an obstruction from adhesions. This is especially true for the cases which have been drained for a considerable time after the operation. During the period when drainage of the general peritoneal cavity for spreading infections was attempted by multiple wicks and incisions, surgeons had an opportunity to observe postoperative obstruction to a degree unknown today. Likewise the history of an old inflammatory process, such as an appendicitis or salpingitis, suggests the possibility of a constricting band. Recurring attacks of severe abdominal pain, sudden in onset and suddenly relieved, may indicate that from a twist of the intestine a partial volvulus has existed in the past or a beginning intussusception which has been spontaneously reduced. Recurring attacks of pain with increasing difficulty in moving the bowels, especially if blood has been noted with the movements, points strongly toward a progressive obstruction of the large bowel from cancer. By such a careful history the possibility of poisoning from

lead or one of the ptomains would be at least indicated, as should also be the evidences of an old specific process which had resulted in a nerve lesion. A painstaking analysis of the acute attack should disclose any possible causes for a reflex paralysis save the intra-abdominal conditions other than acute mechanical obstruction, which may cause a similar syndrome of symptoms. The superficial physical examination may be negative and fail to demonstrate any local condition which might not be simulated by a simple colic or an acute gastro-intestinal attack. The findings may still be negative even after a most careful examination of all the possible sites of herniæ, together with a proctoscopic examination of the rectum and sigmoid; but, as a rule, inspection of the abdomen in a good light will reveal in the cases of mechanical obstruction either an extreme general distention or the local distention of an isolated loop or loops of intestine, with evidence of hyperactive peristalsis. During this inspection visible peristalsis may be seen, particularly if the abdominal wall has been flicked with the finger or a wet towel. If this sign is present with a normally thick abdominal wall the diagnosis of a mechanical obstruction is positive.

Light percussion is extremely valuable in outlining the tympanitic areas as well as in localizing the areas over which light pressure causes pain, and by palpation a mass may be outlined or a sense of deep resistance obtained which is very different from the protective muscle spasm found over an acute inflammatory process.

Auscultation may be of great value in determining not only the presence or absence of intestinal movements, but also in locating the region of an obstruction by the maximum intensity of these movements. The abdominal wall lacks the characteristic telltale protective spasms to be found in inflammatory conditions save as the parietal peritoneum may have become secondarily involved by such an inflammatory process. Pressure, as with simple colic, sometimes gives relief. Even though extreme collapse may not have occurred and the vomiting may not have reached the stage of persistent regurgitation so striking in the extreme conditions and the pulse and temperature as well as the white count may be indeterminate, there is an indescribable evidence of anxiety and tension which these patients show that, coupled with the history and the examination, usually makes the diagnosis relatively easy and positive.

Certain cases of intestinal obstruction should be considered individually when discussing the diagnosis, so specific are their symptoms. Congenital defects, such as an imperforate anus or an occlusion of the small intestine, are evidenced either by a total absence of the normal passage of meconium or the passage of an abnormal content for the newborn infant. With a volvulus the symptoms are usually strikingly acute. The pain is not only that to be referred to the intestinal contractions, but also to the torsion of and the tension upon the mesentery. This mesenteric involvement may cause a pain referred to the back. As the lesion is from the beginning asso-

ciated with extensive circulatory changes in the twisted bowel the absorption of the toxic content begins early and is rapid. The distended and strangulated gut leads to signs of local meteorism. Because of this strangulation and tension, penetration of the wall by bacteria or

FIG. 321.—Resected gangrenous sigmoid due to volvulus.

gross perforation causing peritonitis is an early and a not uncommon sequel.

Intussusception has a symptomatology which is unique. The striking features are that an infant—rarely an older child or an adult—who has previously been well, vomits, cries out with sudden abdominal pain and later passes a mucous or blood-tinged mucous stool. A sausage-shaped tumor may be palpated in the abdomen or a cervix-like mass felt in the rectum by the examining finger. Still later the abdomen may become distended and the collapse is extreme because of the circulatory disturbance caused by the strangulation of the invaginated intestine. The absence of the collapse in the first few hours and the change in pulse-rate may be most misleading. When all these signs and symptoms can be demonstrated the patient is usually beyond surgical relief. A diagnosis should be made irrespective of the profound collapse, and only after an examination under an anesthetic is the statement that no tumor is present justifiable. Specific as is this symptom-complex the following case illustrates a possible confusion between intussusception and appendicitis.

J. B., negro, male, aged thirty-eight years, S. N. 2652. Patient entered the hospital at seven o'clock in the evening with a history of having been seized at ten that morning with severe sharp abdominal pain. He had vomited. There had been no bowel movement since the onset of the pain. The temperature at entrance was 100.2°, pulse 70, white blood cells 13,500. There was distinct tenderness on deep palpation in the right lower quadrant. By rectum an indefinite mass could be felt on the right side high up. The diagnosis of acute appendicitis was made and immediate operation advised. At operation a normal appendix was found and an ileocecal intussusception. This intussusception was reduced without undue trauma. The patient made an uneventful recovery.

This case is atypical in that the patient was an adult, and there had been no movement of the bowels.

Chronic intussusception generally seen in adults is like the diagnosis of a chronic obstruction from new growth—most difficult, being characterized only by indefinite recurring attacks of abdominal pain, possibly accompanied by vomiting and alternating constipation and diarrhea.

When a complete obstruction is superimposed upon a slowly advancing occlusion caused by a new growth the symptoms so overshadow all that might have been noticed before that not infrequently no suggestion of any previous intestinal trouble can be elicited. Without the demonstration of other probable causes of obstruction of the large bowel in an individual beyond forty this may be assumed to be malignant, so frequent is the large bowel the site of cancer. In contrast the studies of Fitz[1] and of Leichtenstern[2] show that in 90 per cent. of all cases of strangulation the small bowel is involved. When

[1] Osler's Practice of Med., Intestinal Obstruction.
[2] Ziemssen's Handbuch, No. 1, vol. viii.

analyzing a suspected case for mechanical intestinal obstruction it must be remembered that the inability of the gastro-intestinal tract to propel the content downward by rhythmical contractions does not constitute a mechanical obstruction, that is a mechanical obstruction which may be amenable to surgical treatment. As has been stated, taking all cases in which there is an inability for one cause or another to empty the gastro-intestinal tract, somewhat less than one-third will be found to be of mechanical nature. In the larger group, however, a definite etiological factor for the intestinal paralysis may be demonstrated by a careful study of the history of the case or by a careful physical examination in the vast majority of patients. The symptoms of tabetic crises may simulate those of intestinal obstruction, but only unjustifiable carelessness in the physical examination and indifference to the case history could lead to a confusion between

FIG. 322.—Carcinoma obstructing colon. Note dilatation and thickening of intestinal wall above the obstruction. (Museum, Washington University Medical School.)

the two conditions. A similar confusion arises in those cases of so-called uremic intestinal obstruction in which the underlying nephritic condition has not been suspected owing to careless failure to examine the urine. Yet it is to be remembered that a patient with nephritis and marked arterial changes may be suffering from an acute intestinal obstruction. This possible confusion is illustrated by the following case history:

J. F., white, aged sixty-five years, S. N. 2989. The patient entered the hospital complaining of vomiting and pain in the right inguinal hernia, which in the past forty-eight hours had on three occasions descended into the scrotum causing severe abdominal pain. He had also experienced during the past year considerable difficulty in voiding urine. There had been no movement of the bowels for several days. The temperature was 99.5° and the pulse 76. The white blood cells

were 9600 at entrance. The physical examination showed relaxed inguinal rings, with a large left inguinal hernia which was readily reduced. Heart sounds irregular and weak. Patient was drowsy. Urine showed a large amount of albumin and many hyaline and granular casts. Blood-pressure 160. The patient was transferred to the medical service with a diagnosis of chronic interstitial nephritis and beginning uremia. Shortly after transfer the patient was suddenly attacked with severe abdominal pain and vomited. On the right side, which had been negative at entrance, except for a relaxed inguinal ring, appeared an irreducible inguinal hernia. The patient was immediately sent to the operating room, and the hernial sac exposed. It contained a moderate amount of blood-tinged fluid and a strangulated loop of small intestine. The bowel was dark, but there was no loss of luster and no question as to its viability. It was therefore returned to the abdominal cavity and the hernia closed. The patient made an uninterrupted recovery. After the operation there was no vomiting. The amount of albumin in the urine decreased, but it continued to be pathological.

To ignore a possible reflex paralysis of the intestine in a patient suffering with renal or hepatic colic would be to ignore a well-recognized cause of intestinal paresia.

Acute intrathoracic processes may also simulate an acute mechanical obstruction. This is especially prone to occur when there is a diaphragmatic pleurisy. A positive differential diagnosis is particularly difficult when there is a central pneumonic process which may give no physical signs. The picture of ileus from its intensity overshadows at the first glance the true etiology, but the sharp rise in temperature, which is never present at the beginning of the intestinal obstruction and the increase in the rate of respiration, together with the facial expression, should indicate that the case is not one of a mechanical obstruction of the bowel.

It may be impossible to differentiate sharply between the mechanical obstruction and certain acute intra-abdominal inflammatory conditions. A paresis of the bowels occurs with the spreading peritonitis and may occur with a local process. This paresis associated with peritonitis as has been stated, will be considered in detail in another section. The typical protective spasm of the abdominal muscles which is to be found with an inflammatory process is absent in the cases of obstruction. The total absence of peristalsis may suggest a paresis rather than an exhaustion from a mechanical obstruction. The white count, except in the terminal stages of a spreading infection, is higher, as a rule, than with the cases of mechanical occlusion, and the amount of free fluid in the peritoneal cavity is greater with a primary inflammatory process than with the obstruction. With the onset of a peritonitis secondary to the obstruction all possibility of a differentiation is lost except by the analysis of the case history and the progress of the disease. Torsion or strangulation of the mesentery or torsion of a tumor pedicle may give a typical ileus syndrome. Trauma of

the testis or of the ovary may cause a reflex splanchnic paralysis. Thrombosis of the mesenteric vessels causes primarily a paralysis of the affected segment of the gut. Until the signs of peritonitis appear the condition is really that of an obstruction. In the second type of case, as recognized by Reich[1] in his study of mesenteric thrombosis, in which there are watery or blood-tinged fluid stools, a differential diagnosis may be made from a mechanical obstruction, but nearly all of the cases of mesenteric thrombosis have been operated upon with a diagnosis of acute mechanical obstruction.

Acute pancreatitis is another one of the acute intra-abdominal inflammatory conditions in which a positive diagnosis can be made only at operation. On opening the abdomen the finding of the pearl-white areas of fat necrosis is pathognomonic. Acute dilatation of the stomach also simulates an acute intestinal obstruction in the suddenness of the onset and the degree of the collapse, but the diagnosis of this condition is readily made by the use of the stomach-tube.

Treatment.—A discussion of possible medical treatment is pertinent only in a consideration of the cases of ileus without a mechanical obstruction. For a mechanical obstruction of the bowel there is no logical treatment other than operation for the relief of the obstruction. The failure to differentiate sharply between ileus caused by a paralytic or spastic condition of the bowel and that caused by a mechanical obstruction has led to confusion of ideas as regards the possibilities of cure by non-operative means. In no other intra-abdominal condition is the early diagnosis and proper treatment so essential, if life is to be saved, as in these cases of acute mechanical obstruction.

With a primary inflammatory process the natural protective mechanism may limit the progress of the inflammation. The resulting paralysis of the intestine is without doubt an effort on the part of Nature to limit the extent of the peritonitis. With a mechanical obstruction there is no protective mechanism. Every reaction tends to augment the absorption of the toxic content from the bowel by increasing the tension within the lumen. As a first possible step in relieving this tension within the gastro-intestinal tract the stomach should be emptied, since with an empty stomach the overflow from the intestine is favored.

Any attempt by cathartics to stimulate a peristalsis sufficiently violent to overcome the obstruction is contra-indicated. In certain types of obstruction, by the very violence of the peristalsis, the obstruction is made complete. In such cases a relaxation of the intestinal tone from morphin or atropin might be theoretically beneficial, but by the use of opiates the symptoms may be dangerously masked. Drugs should not be given until a positive diagnosis has been made and a definite course of treatment determined upon. The usual heart stimulants, caffein, camphor or strychnin, are of questionable value.

[1] Ergeb. d. Chir. u. Orth., 1913, xii, 515.

Except for those cases which are seen before there has been any considerable absorption these patients are toxic and many of them on the verge of collapse, even though there may be little or no evidence of this from the pulse and temperature. Therefore, every effort must be made to reduce to a minimum the operative shock. When it is possible a local anesthetic is always to be preferred to a general: (1) Because of the elimination of the depression of the general anesthetic, and (2) to minimize the danger of inhalation of the regurgitant stomach content while the protective reflexes are lost. Except in children and in the very unusually neurotic patients a local anesthetic should always suffice for all operations on strangulated herniæ. For the exploration of the peritoneal cavity a general anesthetic will be necessary, but this may with advantage be supplemented by using the local for the section of the abdominal wall. The choice in the general anesthetic, provided it is not chloroform, may be left to the preference of the individual operator. Personally I prefer gas and oxygen with an amount of ether sufficient only to afford proper relaxation.

Since the dehydration in these cases may be extreme, active measures should be instituted to replace this loss. A subpectoral infusion of 1000 c.c. normal salt solution before the operation is an admirable preparation. Transfusion of blood is without special effect in these cases, just as it is in other cases toxic from infections. The operation must be performed with a minimum amount of trauma and without hemorrhage. Excessive trauma of the normal intestine may cause a paralysis which exists for a considerable time. Even moderate trauma in these cases of obstruction may cause a serious paresis, and trauma also tends to increase the amount of absorption from the lumen. With the extreme distention of a considerable portion of the intestine or with a large distended loop from a strangulation or a volvulus the avoidance of excessive manipulation is most difficult. To facilitate this aspiration of the bowel content after a most careful preparation to prevent soiling of the peritoneum may change a difficult or impossible operation into a relatively easy one. The insertion of a tube into the coils of intestine for the withdrawal of the content, as has been advocated by some, is I believe, a most dangerous procedure. By this procedure the mucous membrane is still further traumatized, a more rapid absorption of the content is made possible, and it is inconceivable that all of the toxic content can be removed. Apprehension has been felt lest there be absorption of this toxic content after it had passed into the intestine below the obstruction. This fear is groundless. No absorption of this toxic substance from the bowel lumen occurs with a normal mucous membrane.

Probably no single manipulation in these cases adds so greatly to the operation shock as evisceration. If evisceration is necessary the intestine must be most carefully protected by hot compresses. The operator who will judiciously aspirate distended loops and exercise due care in his exploration will find it rarely necessary to eviscerate any considerable part of the intestine.

Bearing in mind that operations in these cases are life-saving measures on patients with very little reserve, a lateral anastomosis between the distended and constricting intestine, as near as possible to the site of the obstruction, may be successful when a prolonged operation for the removal of the obstruction would have been fatal. Prolongation of an operation beyond the absolute minimum of time necessary for relieving the obstruction is unjustifiable. The value of an enterostomy above the level of the obstruction has been much discussed and many operators are of the opinion that it is a valuable procedure. Provided the mechanical obstruction has been removed I question if the bowel content will drain any more rapidly through the enterostomy opening than into the normal intestine. The drainage of any considerable part of the intestinal tube is possible only with a return of the peristaltic activity of the bowel. With a return of this propelling power the content will be forced into the normal intestine and be advanced by the action of the gut below the obstruction. In consequence, only with a paralysis from the strangulation of a loop in which the viability may be questioned or a prolonged paresis feared is enterostomy drainage indicated, and then only with the purpose of draining that immediate loop. Enterostomy has a particular value in cases of volvulus when the prolonged strangulation may tend to a paralysis of that part of the bowel which has been twisted.

No other operative problem in surgery requires greater judgment or greater skill than the successful treatment of a loop of bowel which has been strangulated. The temporary replacement within the abdominal cavity or protection with warm compresses may cause a rapid return to normal in the appearance of the gut. In the frank cases in which the luster of the intestine has been lost and when there is evident thrombosis of the mesenteric vessels with beginning gangrene of the bowel wall, there is no alternative but to resect. With the questionable cases, however, especially if the strangulation has involved only a limited extent of bowel, the danger of later necrosis is not to be compared with the incomparably greater danger of immediate resection, particularly if the general condition of the patient is not good. These questionable loops should be returned to the abdominal cavity and protected by wrapping the omentum around them. By this procedure a limited amount of the intestinal wall may retain its viability when it seemed lost. In such cases, drainage to the region of the damaged loop may be indicated.

When resection is imperative the method of operating must vary with the experience and skill of the operator. As routine the two-step operation will make it possible to save cases in which the completed operation of section and resuture of the bowel would be fatal. In the cases of simple obstruction so toxic from the continued absorption that a removal of the obstruction or a lateral anastomosis around the obstruction is not possible, the distended intestine should be drained by an enterostomy tube. In the cases in which a section

of the bowel is non-viable and must be removed the damaged intestine is resected at the first operation, care being taken to go well above the level of the strangulation in order to be beyond any thrombosis of the mesenteric vessels. The ends of the intestine are then brought out through the abdominal wall or drained through rubber or glass tubes. In cases of high obstruction this plan of operating may not be so applicable because of interference with nutrition. The content discharged from the upper loop may, however, be collected and injected into the lower, or the nutrition may be satisfactorily maintained by the injection of liquids into the lower segment direct. Later, when the condition of the patient justifies a second operation, the ends of the intestine may be joined, usually without difficulty and under a local anesthetic. If care has been taken to

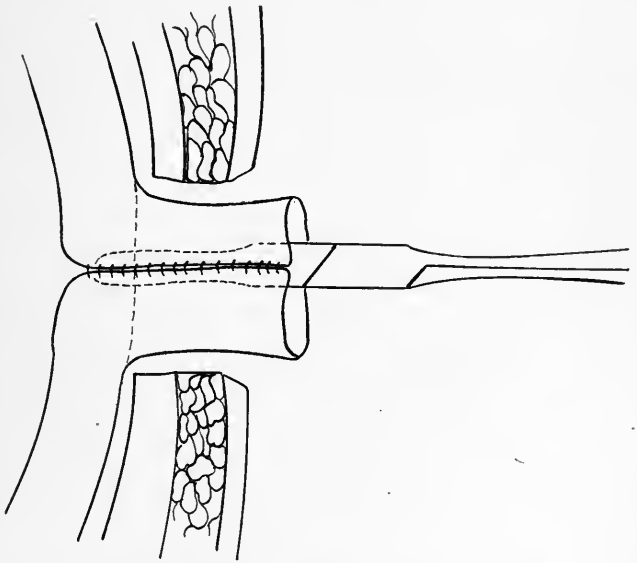


FIG. 323.—Method of effecting closure of fecal fistula without operation.

approximate the loops of intestine when they are withdrawn through the abdominal wall it may be possible to open the bowel walls by pressure forceps so that the content will discharge directly from one segment to the other, and this may lead to the closure of the fecal fistula without operation. Drainage in these cases of mechanical obstruction is indicated only for a beginning or suspected peritonitis. The free fluid found in the abdominal cavity with an obstruction without peritonitis is never toxic.

As in the discussion of diagnosis the treatment of the conditions of imperforate anus and intussusception should be considered individually. With an imperforate anus an effort to reach the dilated closed rectal segment should always be made from below. In this exploration, except in the cases in which the obstruction consists of

a relatively thin diaphragm in the anal canal, the dissection must be continued in the medial line posteriorly and upward toward the hollow of the sacrum. If the distended rectal pouch is not readily reached it should be remembered that a fistulous opening through the vagina in girls or an artificial anus in either sex is to be preferred to a prohibitively long operation on those young children in whom operative shock, especially if the loss of heat has not been guarded against, is great. The rare recovery effected by the sloughing into the bowel of the intussusceptum is the exception like the perforation of a strangulation of a part of the gut wall in herniæ, to emphasize the rule, "Always operate for intussusception, and at once, as soon as the diagnosis is made."

The statistics of Clubbe[1] emphasize most graphically the effect of time upon the prognosis in intussusception in children. In his series of cases the average time from the onset of symptoms to operation was in the first 50, in the cases that lived, twenty-four hours; and in the cases that died, sixty-eight hours; in the second 50, in the cases that lived, twenty-three hours, and in the cases that died, forty-eight hours. To delay the diagnosis into the second twenty-four-hour period is to ensure almost a fatal result.

Opinions differ as to the wisdom of attempting in these cases to reduce the intussusception by the distention of the bowel by warm oil or salt solution enemata. Unquestionably, intussusceptions have been reduced by this method. To me it has always seemed to be an uncertain and dangerous procedure. The mechanism of the procedure of intussusception must be remembered in operations attempting its reduction. Pressure upon the apex of the intussusceptum, with gentle taxis, will almost always be effective when a direct pull upon the bowel will cause a rupture of the peritoneal coats or possibly a complete tear across the wall. Every effort must be made to reduce the intussusception rather than to resect the entire mass, so prohibitively high is the mortality after these extensive operations. If a resection is necessary the same procedure as described for the treatment of the bowel after resections for strangulation may be used to advantage. When any cause for the intussusception can be demonstrated this must be remedied.

Following the operation in every case of intestinal obstruction the salt solution should be continued subpectorally or tap water or salt solution given per rectum by any one of the accepted methods. By the drop method of the late John B. Murphy enormous quantities of liquid may be introduced into and absorbed from the rectum. By the use of small enemata, not to exceed 300 to 400 c.c., given into the rectum every three to six hours, an ample amount of fluid is supplied. The essential in any method of proctoclysis is not to overdistend the bowel. When the rectum becomes irritable deodorized tincture of opium should be added to the enema. A sufficient

[1] British Med. Jour., June 17, 1905.

amount of morphin should be given to relieve the patient from excruciating pain. The paralyzing effect upon the intestine, so dreaded by some, need not be apprehended with the intelligent use of moderate amounts of this drug. Attempts to simulate peristalsis by cathartics are, as a rule, absolutely ineffectual. Unless the use of enemata is contra-indicated by some local condition of the large bowel some one of the stimulating enemata should be used to empty this section of the gastro-intestinal tract. Cathartics are indicated and effective only after the intestine has recovered its normal tone.

The position of the patient should be that affording the greatest comfort. This is usually a moderately high bed rest. Especially is this position acceptable if the distention embarrasses in any way the movements of the diaphragm.

Spastic Ileus.—A spastic contraction of the muscles of the gastro-intestinal tract, together with edema of the tissues, may so constrict the lumen of the bowel that intestinal obstruction results. This condition, called spastic or dynamic ileus, is so constantly referred to that it seems unwise not to mention it in a discussion of intestinal obstruction. Although an actual obstruction of the intestinal lumen does occur and the ileus syndrome is simulated, these cases should not be considered primarily as cases of intestinal obstruction. Freeman[1] describes the appearance of the intestine in a patient who had an operation for the symptoms or acute intestinal obstruction. A segment of ilium, five or six inches in length, was contracted to the point which it appeared bloodless. The bowel proximal to the contracted segment was distended and the bowel distal to the contraction was collapsed. The contracted segment relaxed after the abdomen was opened. The patient recovered without further symptoms. Freeman believes this condition is to be regarded as a reflex phenomenon, and that it is more frequent than generally supposed. Payr[2] believes that these localized spastic contractions of the intestines are the result of embolism of the mesenteric vessels. The condition is most commonly associated with poisoning from lead or a ptomain. In an experimental study of the effect of lead-poisoning, Harnack[3] emphasizes the important role which the circulatory change plays in the production of the edema of the gut wall. The pain is attributed to violent contractions of the intestinal muscles. The diagnosis of this condition depends essentially upon the establishment of the etiology. The combination of pain, vomiting and collapse may simulate closely the results of a mechanical intestinal obstruction. The treatment is that indicated for the special toxin.

Paralytic Ileus.—A paralysis of the intestine may result from conditions affecting the intestine directly, as trauma or intra-abdominal infection, or from reflex paralysis of the motor mechanism, or as a part of a severe general systemic depression. This condition of acute paralysis of the intestine is to be differentiated sharply from the

[1] Ann. Surg., 1918, lxviii, 196.
[2] Quoted by Freeman.
[3] Arch. f. exp. Path., vol. ix.

so-called atonic inertia, which is associated with a general ptosis. Clinically, acute paralytic ileus forms more than two-thirds of all cases which present the ileus syndrome. It is in this group of cases in which recoveries without operation are reported and it is the clinical experience in this group of cases which has led to the dangerous doctrine of delay in cases of mechanical obstruction in the hope that recovery may take place without operation.

Of the causes of acute paralytic ileus the most frequent is a spreading intra-abdominal infection. The paralysis resulting from a spreading intraperitoneal infection might be considered as the result of the general systemic depression, but it is so characteristically associated with infection within the abdominal cavity and plays such an important role in the localization of this infection that it seems more likely to be the result of a direct influence on the intestinal motor mechanism. As was stated previously this phase of intestinal obstruction will be dealt with in another section.

Etiology.—The studies of Magnus,[1] Bayliss and Starling[2] and Cannon[3] have demonstrated that the movements of the gastro-intestinal tract are controlled by intrinsic and extrinsic nerves. The essential part of the intrinsic nervous mechanism is formed by Auerbach's plexus, which lies between the circular and longitudinal coats. Governed by this intrinsic innervation, the intestine will perform the normal movements of rhythmic contraction though completely isolated from the central nervous system. The intrinsic nervous mechanism may be temporarily interfered with by a section of the nerves connecting it with the central nervous system, but later the normal intestinal movements are resumed. The extrinsic innervation of the intestine is received through the vagi, the sympathetic and the sacral autonomic systems. In general the sympathetic system tends to inhibit and the vagus and sacral nerves to stimulate gastro-intestinal movements. Theoretically, then, a paralysis of the gastro-intestinal tract may result from an abnormal overactivity of the sympathetic system or an abnormal inactivity of the vagi or sacral nerves.

Pathology.—The pathology depends upon the etiology. Inflammatory reaction or interference with the nutrition of the intestine may interfere with the intrinsic innervation; lesions of the central nervous system may interfere with the extrinsic nerves. Severe general depression may so reduce the muscle tone of the intestine that normal movement is inhibited. The paralysis resulting from the manipulation of the bowel or from the trauma secondary to incarceration or strangulation of the intestine is evidently the result of interference with the intrinsic nervous mechanism. This was demonstrated experimentally by the observations of Cannon and Murphy.[4]

[1] Arch. f. d. ges. Physiol., 1904, vol. ciii; 1906, vol. cxi.
[2] Jour. Physiol., 1899, vol. xxiv; 1900, vol. xxvi.
[3] Mechanical Factors of Digestion.
[4] Ann. Surg., 1906, vol. xliii; Jour. Am. Med. Assn., 1907, vol. xlix.

They found that the intestine could be paralyzed for variable periods of time, depending upon the degree of trauma inflicted, and that this paralysis was not influenced by section of the connections between the intrinsic nervous mechanism and the central nervous system. Lesions in the mesentery may affect both the intrinsic and extrinsic nerves. Thus, for example, following mesenteric thrombosis, there is primarily a paralysis of the portion of intestine which is deprived of its nutrition, and, secondly, a paralysis of other parts of the intestine due to the effects of the spreading infection. Any lesion which interferes with the vagi or a lesion of the spinal cord which interferes with the sympathetic or sacral autonomic system interferes directly with the extrinsic nerve control. Reflex inhibition of peristalsis, which is received by way of the splanchnic nerve, is usually associated with sudden severe pain, as, for example, that of hepatic or renal colic or following trauma to the testis or ovary or as the result of torsion of the omentum or a tumor with a pedicle. Trauma of the abdominal wall may also cause complete reflex inhibition of intestinal movements. Overwhelming acute infections, such as acute hemorrhagic pancreatitis, may also cause cessation of intestinal movements. The intestinal paralysis of typhoid, uremia and other general depressive conditions is to be attributed to general loss of muscle tone.

Symptoms.—In all these conditions of acute paralysis of the intestine the most striking symptoms may be those of ileus, yet the general appearance of the patient, as a rule, guides the careful observer away from error. Save for cases of mesenteric thrombosis or overwhelming intra-abdominal infection the extreme collapse seen in true intestinal obstruction is never found. The distention, though it be extreme, is characterized by flaccidity. Visible peristalsis is not present, and even auscultation fails to demonstrate any evidence of peristalsis.

Diagnosis.—The diagnosis consists primarily in eliminating the possibility of a mechanical obstruction and recognizing the primary cause of the paralysis. The patient's history must be considered most carefully for any possible etiology. If there has been direct trauma to the abdomen the differential diagnosis is between a reflex paralysis of the intestine and a rupture of an intra-abdominal organ. Given such a problem an experienced surgeon will prefer to explore rather than speculate about the intra-abdominal condition, because of the great danger of delay and the relative safety of exploration. If the symptoms of acute paralytic ileus develop after an intra-abdominal operation the paralysis may be due to trauma to the intestines or mesentery or may be the result of a spreading intra-abdominal infection. Fortunately, postoperative paralytic ileus is not now frequently seen. The technic of handling the intestines has been perfected and also modern aseptic methods have practically eliminated the danger of intra-abdominal infection. An appreciation of the physiology of the nervous control of the intestinal tract explains the paralytic distention following an injury to the spinal cord. The same is true of the distention, associated with renal or hepatic colic

or trauma to the testis. With such intra-abdominal conditions as torsion of the omentum or twisting of a tumor pedicle the differential diagnosis may not be possible save by exploration, a step necessary in the treatment of either condition. Acute intrathoracic diseases, especially pneumonia of the lower lobes or a pleuritis of the diaphragmatic pleura, may be associated with reflex intestinal paralysis, which is explained only after the recognition of the intrathoracic disease.

Treatment.—The first and most important step in the treatment of acute paralytic ileus is to remove the cause of the paralysis. Symptomatic treatment may then be carried out as indicated. The actual effect of drugs may be questioned. With interference with the intrinsic nervous mechanism, local irritants may help. Atropin may prevent inhibition. Eserine and the recently introduced glandular extracts are of questionable value; in short, there is no specific treatment for acute paralytic ileus. When the disturbed mechanism of the innervation is reëstablished or when the system has recovered from the effect of general depression, peristalsis automatically becomes normal. The failure to treat these conditions correctly is usually due to a failure to appreciate the fact that the condition is a paralysis and not a true obstruction, or to the placing of too great reliance on the efficacy of treatment by drugs. Much more reliance should be placed in the judicial use of the stomach-tube, enemata and application of hot turpentine stupes directly to the abdomen. Jutte[1] recommends the use of transduodenal lavage with a warm hypertonic salt solution by means of the duodenal tube. He believes that such a procedure is a stimulus to peristalsis of the entire intestinal canal. Theoretically the administration of morphin is to be avoided, but practically if the patient is restless a sufficient dose of morphin given hypodermically, to give the patient a few hours complete rest, often leads to an immediate resuming of the normal intestinal peristalsis.

[1] Jour. Am. Med. Assn., 1919, lxxii, 929.

INDEX

A

Abbe's string method of treatment of cicatricial stenosis of esophagus, 72
Abdomen, examination of, in diagnosis of diseases of stomach, 567
in splenic anemia, 523
Abdominal aorta, aneurysm of, diagnosis of, from cysts of pancreas, 485
palpation in pyloric stenosis, 636
tenderness in gastric ulcer, 622
in ulcer of duodenum, 695
tumor in cancer of stomach, 671
in pyloric stenosis in infancy, 602
wall, abscess of, diagnosis of, from cysts of pancreas, 485
Abnormal involution of breast, 157
Abnormalities of pancreas, 437
Abscess of abdominal wall, diagnosis of, from cysts of pancreas, 485
of breast, 150
of cavity of great omentum, 802
of esophagus, 46
of liver, 372
complications of, 374
diagnosis of, *x*-rays in, 375
fever in, 373
leukocytosis in, 373
Muhlman's operation in, 375
pain in, 373
symptoms of, 373
treatment of, 375
of omentum, 792
of pancreas, diagnosis of, from cysts, 485
pulmonary, 274
chronic simple, bronchiectasis and, treatment of, 276
diagnosis of, 274
x-rays in, 274
prognosis of, 276
putrid, bronchiectasis and, 277
resection of lung in, 275
treatment of, 275
of spleen, 517
diagnosis of, 518
pathology of, 517
prognosis of, 518
symptoms of, 518
treatment of, 518
of subpleural connective tissue, 249
of thoracic wall, 243
diagnosis of, 246
Abscess of thoracic wall, symptoms of, 245
treatment of, 246
Accessory pancreas, 437
Ach's esophageal extractor, 90
Achylia gastrica, diagnosis of, from cancer of stomach, 685
Acidity, gastric, 579
tests for, 580
Actinomycosis of breast, 155
of liver, 376
of thorax, 249
Adenocarcinoma of breast, 177
of stomach, 662
Adenofibroma of breast, 165
Adenosarcoma of breast, 167
Adhesions in gastric ulcer, 632
Air-tight thoracic drainage after thoracic operations for carcinoma of esophagus, 106, 107
Amastia, 141
Amazia, 141
Anemia, pernicious, 539
blood in, 543
diagnosis of, 540
from splenic anemia, 525
etiology of, 539
hemolysis in, 543
pathology of, 540
splenectomy in, 544
transfusion of blood in, 542
treatment of, 541
splenic, 520
abdomen in, 523
adult type of, in children, 527
anemia in, 524
ascites in, 524
cardiac symptoms in, 524
cholelithiasis and, 521
diagnosis of, 525
etiology of, 521
fever in, 524
hematemesis in, 523
Hodgkin's disease and, 522
incidence of, 522
of infancy, 528
pain in, 523
pathology of, 522
renal complications in, 524
splenectomy in, 527
symptoms of, 523
treatment of, 526
in ulcer of duodenum, 690, 694
Anemias, grave, diagnosis of, from cancer of stomach, 681

Anesthesia in thoracic surgery, 208
Aneurysm of abdominal aorta, diagnosis of, from cysts of pancreas, 485
aortic, compression stenosis of esophagus and, 60
of hepatic artery, 384
traumatic, fractures of ribs and, 226
Angioma of breast, 173
of liver, 377
of spleen, 516
Angustatio ventriculi, 600
Annular pancreas, 437
Anoci-association in intrathoracic surgery, 209
Anomalies of esophagus, congenital, 49
of stomach, congenital, 599
Anterior gastro-enterostomy, 752
Aorta, abdominal, aneurysm of, diagnosis of, from cysts of pancreas, 485
Aortic aneurysm, compression stenosis of esophagus and, 60
Apoplexy, pancreatic, 499
Appetite, diagnosis of diseases of stomach and, 566
in gastric ulcer, 621
in ulcer of duodenum, 694
Arteriosclerosis, acute pancreatitis and, 455
Ascites in carcinoma of pancreas, 496
in splenic anemia, 524
Athelia, 141
Atresia of duodenum, 704
of stomach, 599
Atrophy of breast, 147
of stomach, 703

B

Bacteriology of duodenum, 704
of stomach, 704
Balfour-Gossit retractor, 91
Banti's disease, 520. *See* Anemia, splenic.
von Bechterew's disease, 202
Beck-Jianu operation for carcinoma of esophagus, 121
Beck's bismuth paste in treatment of empyema, pleural and pulmonary fistulæ, 285
of wounds of diaphragm, 329
Belching of sour gas in ulcer of duodenum, 693
Benign pyloric stenosis, 633
Bevan's incision in splenectomy, 550
Beyea's method of gastropexy, 743
Bile ducts, carcinoma of, 408
direct implantation of, 423
inflammation of, 393
operations on, 410
reconstruction of, 422
Biliary fistula, 407
Blood in cancer of stomach, 674
Blood in gastric ulcer, 624, 625
in Gaucher's disease, 532
in hemolytic jaundice, 536
"occult," diagnosis of diseases of stomach and, 580, 591
in pernicious anemia, 543
supply of spleen, 503
in syphilis of stomach, 655
transfusion of, in pernicious anemia, 542
in wounds of chest, 324
Blood-pressure, intrathoracic surgery and, 206
Bradycardia in injuries of liver, 362
Brauer's overpressure apparatus in intrathoracic surgery, 214
Breast, abnormal involution of, 157
abscess of, 150
treatment of, 152
actinomycosis of, 155
adenocarcinoma of, 177
adenofibroma of, 165
adenosarcoma of, 167
anatomy of, 139
angioma of, 173
atrophy of, 147
broken, 150
carcinoma of, 174
classification of, 176
colloid, 178
diagnosis of, 183
etiology of, 174
growth of, 180
prognosis of, 184
symptoms of, 180
treatment of, 186
drainage in, 192
exploratory operations in, 193
palliative operations in, 194
radium in, 186
skin incision in, 186
supraclavicular dissection in, 192
x-rays in, 186
contusions of, 143
cystosarcoma phyllodes of, 167
proliferum of, 167
cysts of, 157
cancer, 179
due to new growths, 163
development of, 139
diseases of, cystic, 157
treatment of, 162
functional, 146
inflammatory, 149
echinococcus of, 155
enchondroma of, 173
fibro-adenoma of, 165
fibrocystadenoma of, 171
fibroma of, cystic, 165
fibromyxoma of, 165
foreign bodies in, 143
hematoma of, 143
hysterical, 146
hypertrophy of, diffuse, 147

Breast, hypertrophy of, infantile, 148
senile parenchymatous, 157
injuries of, 143
intracanalicular papillary fibroma of, 165
lipoma of, 173
male, cysts of, 197
diseases of, 196
injuries of, 196
malformations of, 196
tumors of, 197
malformations of, 141
neuralgia of, 146
osteoma of, 173
papillary cystadenoma of, 169
papilloma of, villous, 169
sarcoma of, 173
cystic, 167
syphilis of, 153
tuberculosis of, 154
tumors of, 163
fibro-epithelial, 165, 168
non-indigenous, 172
wounds of, 143
"Broken" breast, 150
Bronchi, foreign bodies in, 277
bronchoscopy for, 278
mediastinal bronchotomy for, 280
Bronchiectasis, 285
"collapse" therapy in, 287
diagnosis of, 286
x-rays in, 286
pneumotomy in, 287
pulmonary abscesses and, 277
treatment of, surgical, 287
Bronchoscopy for foreign bodies in bronchi, 278
Bronchotomy, mediastinal, for foreign bodies in bronchi, 280
Brüning's illuminating handle for esophagoscope, 34
saliva aspirator, 35
Burns, duodenal ulcer and, 764

C

Calculi, pancreatic, 488
diagnosis of, 490
x-ray in, 490
etiology of, 489
glycosuria in, 490
pain in, 489
symptoms of, 489
treatment of, 491
vomiting in, 489
Callman's sound, 32
Cancer cysts of breast, 179
duct, 169
of stomach, 658, 708
abdominal tumor in, 671
age and, 659
blood in, 674
cachexia in, 671
Cancer of stomach, changes in stomach produced by, 664
colloid, 662
complications of, 685
course of, 646
definition of, 658
diagnosis of, 679
from achylia gastrica, 685
from chronic constipation, 685
from foreign bodies, 685
from gall-bladder disease, 681
from gastric granuloma, 685
from grave anemias, 681
from lues, 685
from tuberculosis, 685
from tumors of kidney, 685
of large intestine, 685
of omentum, 685
enteritis in, 686
fibrous, 662
fistula in, 686
gastric acidity in, 672
contents in, microscopic examination of, 674
ulcer and, 661
gastroscopy in, 679
gelatinous, 662
habits and, 660
hemorrhage in, 669
heredity and, 659
"hour-glass" in, 686
hygiene and, 661
incidence of, 659
jaundice in, 686
location of, 663
malaria and, 661
medullary, 662
metastases in, 665
morbid anatomy of, 661
mucoid, 662
nature of, 646
obstruction at cardia in, 685
occupation and, 660
operations for, contra-indications to, 709
exploratory incision in, 709
gastrectomy, 710
complete, 718
partial, 711
subtotal, 718
gastro-enterostomy, 709
gastro-esophagostomy, 710, 719
gastrostomy, 711
indications for, 709
jejunostomy, 711
pylorectomy, 711
origin of, 646
perforation in, 686
pyloric obstruction in, 685
race and, 659
rheumatism and, 661
roentgen examination in, 677

Cancer of stomach, scirrhus, 662
secondary, 663
sex and, 659
signs of, 665
social status and, 660
symptoms of, 665
syphilis and, 661
test-meal in, 672
thrombosis in, 686
trauma and, 660
treatment of, 708
tuberculosis and, 661
ulcerating, 662
vomiting in, 670
Cancerous mastitis, 179
Carbuncles of chest-wall, 240
Carcinoma. *See* also Cancer.
of bile-ducts, 408
of breast, 174
classification of, 176
colloid, 178
diagnosis of, 183
etiology of, 174
growth of, 180
prognosis of, 184
treatment of, 186
of esophagus, 78
esophagoplasty for, 85, 117, 119
occurrence of, 78
posterior mediastinotomy for, 88
preliminary gastrostomy for, 89
resection for, 83, 87
of cardia for, 107
symptoms of, 79
transthoracic operation for, 89
treatment of, 80
operative, palliative, 117
radical, 82
type of, 78
of gall-bladder, 408
of liver, 377
secondary, 380
treatment of, 377
of lung, 256
of omentum, 795
of pancreas, 494
ascites in, 496
diagnosis of, 494
edema in, 496
extirpation in, 497
glycosuria in, 496
jaundice in, 495
pain in, 495
symptoms of, 494
treatment of, 497
operative, 499
of pleura, 255
diagnosis of, 257
symptoms of, 257
of stomach, 658. *See* Cancer of stomach.
Cardia, resection of, for carcinoma of esophagus, 107
Cardiac symptoms in splenic anemia, 524
Cardiodilator, Einhorn's, 53
Cardiodilator, Plummer's hydrostatic, 53
Cardioplasty in treatment of spastic stenosis of esophagus, 57
Cardiospasm, 50
cardioplasty for, 57
diagnosis of, 51
esophagogastrostomy for, 58
etiology of, 51
treatment of, 52
Carmin test in pyloric stenosis in infancy, 602
Catarrhal cholecystitis, acute, 393
Chest, deformities of, 199
congenital, 199
phlegmon of, 242
wounds of, 313
penetrating, 315
collapse of lung in, 316
gangrene of lung and, 326
hemoptysis in, 315
operations for, 317
pneumothorax in, 316
signs of penetration in, 315
streptococcic infection in, 324
transfusion in, 324
x-rays in, 316
superficial, 314
Chest-wall, carbuncles of, 240
cold abscess of, 243
diagnosis of, 246
treatment of, 246
cysts of, echinococcus, 251
enchondroma of, 254
furuncles of, 240
sarcoma of, 254
suppurations of, 240
tumors of, 253
Chicken-breast, 201
Chicken-pox, acute pancreatitis and, 447
Cholecystectomy, 418
Cholecystenterostomy, 421
Cholecystgastrostomy, 421
Cholecystitis, 393
acute catarrhal, 393
complications of, 402
diagnosis of, 401
pain, 401
pancreatitis and, 447
symptoms of, 401
treatment of, 405
chronic, 395
treatment of, 406
complications of, 400
etiology of, 398
suppurative, 394, 395
Cholecystostomy, 416
Cholecystotomy of Bernay's, 416
Choledocho-enterostomy, 422
Choledochotomy, 419
retroduodenal, 420
Choledochus cyst, congenital idiopathic, 390
Cholelithiasis, 402. *See* also Gall-stones.
acute pancreatitis and, 447

Cholelithiasis, heart in, 403
jaundice in, 403
pain in, 403
splenic anemia and, 521
symptoms of, 402
Chondrectomy in treatment of emphysema of lungs, 290
Chondrosternal dislocations, 228
Chondrotomy in treatment of congenital, rigid and dilated thorax, 291
Cicatricial stenosis of esophagus, 67
treatment of, 68
operative, 70
Cirrhosis, Hanot's, diagnosis of, from splenic anemia, 526
of liver, 369, 546
diagnosis of, from splenic anemia, 526
pathology of, 369
splenectomy in, 547
treatment of, 370
of stomach, 707
gastrectomy for, 707
x-rays in diagnosis of, 707
Coffey's method of gastropexy, 743
Cold abscess of thoracic wall, 243
Collapse of lung in wounds of chest, 316
therapy in treatment of bronchiectasis, 287
Colloid carcinoma of breast, 178
of stomach, 662
"Combined" acidity, diagnosis of diseases of stomach and, 580
Commotion of thorax, 221
Compression stenosis of esophagus, 59
of thorax, suffocative, 221
Concretions of pancreas, 488
Congenital anomalies of esophagus, 49
of gall-bladder, 389
of stomach, 599, 704
deformities of chest, 199
of ribs, 199
diaphragmatic hernia, 606
elevation of diaphragm, 605
enlargement of stomach, 603
faulty position of stomach, 603
funnel-chest, 201
hypertrophic pyloric stenosis, 600, 773
idiopathic choledochus cyst, 390
malformations of pancreas, cysts and, 476
narrowing of superior thoracic aperture, 202
presternal cyst, 253
pyloric stenosis, 725, 773
rigidity of costal cartilages, 202
spastic pyloric stenosis, 773
thoracic rigidity and emphysema, 202
Constipation in chronic pancreatitis, 470
diagnosis of, diseases of stomach and, 566
in gastric ulcer, 621
in pyloric stenosis in infancy, 601
in ulcer of duodenum, 694
Contracted stomach, 600, 703
Contraction of thorax, 204
Contusions of breast, 143
of thorax, 220
Costal cartilages, dislocations of, 228
fractures of, 227
prognosis of, 228
symptoms of, 228
treatment of, 228
rigidity of, 202
Costochondral dislocations, 228
Costovertebral dislocations, 228
Cracks of nipple, 144
Crump's stilette, 38
Cruveilhier's deformity of ribs, 201
Cyanosis in acute pancreatitis, 453
Cyst, choledochus, congenital idiopathic, 390
Cystadenoma of breast, 157
papillary, 169
diagnosis of, 171
treatment of, 171
of pancreas, 493
Cystic fibroma of breast, 165
lymphangioma of omentum, 794
mastitis, chronic, 157
neoplasms of pancreas, 476
omentum, 794
sarcoma of breast, 167
of omentum, 796
Cystocotomy, 417
Cystosarcoma phyllodes of breast, 167
proliferum of breast, 167
Cysts of breast, 157
cancer, 179
of cavity of great omentum, pancreatic, 802
sanguineous, 802
of chest-wall, echinococcus, 251
congenital presternal, 253
of kidney, diagnosis of, from cysts of pancreas, 486
of liver, echinococcus, diagnosis of from cysts of pancreas, 485
of lungs, 252
of male breast, 197
of mesentery, diagnosis of, from cysts of pancreas, 485
of omentum, parasitic, 796
retention, 794
of pancreas, 475
congenital malformation and, 476
diagnosis of, 480
x-rays in, 484
drainage in, 488
exudative, of omental sac, 478
pain in, 482
proliferation, 476
retention, 476
by self-digestion, 477
situation of, 478
size of, 478
by softening, 477
symptoms of, 480
treatment of, 486

Cysts of pancreas, true, 476
of round ligament, diagnosis of, from cysts of pancreas, 485
of spleen, 514
dermoid, 514
diagnosis of, 516
from cysts of pancreas, 485
dyspnea in, 516
echinococcus, 514
hemorrhagic, 515
lymphatic, 515
non-parasitic, 514
pain in, 515
serous, 515
symptoms of, 515
treatment of, 516
of stomach, 724
of thorax, 251
echinococcus, 251

D

Decortication of lung for empyema, 272
Dowd's technic of, 273
Deformities of chest, 199
congenital, 199
of ribs, congenital, 199
of thorax, diseases of vertebræ and, 202
Depression of nipple, 143
Dermoid cysts of spleen, 514
Diaphragm, congenital elevation of, 605
anatomic variations in, 605
differential diagnosis of, 606
etiology of, 605
morbid anatomy of, 605
signs of, 605
symptoms of, 605
wounds of, 326
closure of, 326
postoperative care of, 327
treatment of, Beck's bismuth paste in, 329
late, 329
Diaphragmatic hernia, 235
acquired, 607
clinical history in, 607
fluoroscopic examination in, 607
Litten's sign in, 607
physical signs in, 607
congenital, 606
prognosis of, 235
treatment of, 235
Diarrhea in chronic pancreatitis, 470
diagnosis of diseases of stomach and, 567
in gastric ulcer, 621
Diffuse hypertrophy of breast, 147
Digestive disturbances in splenic anemia, 524
Dilatation of stomach, acute, 727
Dilated thorax, treatment of, chondrotomy in, 291
Diphtheria, acute pancreatitis and, 447
Dislocations, chondrosternal, 228
of costal cartilage, 228
costovertebral, 228
costrochondral, 228
of ribs, 228
Displacements of liver, 359
Diverticula of duodenum, 704
of esophagus, pressure, 61
pulsion, 61
of stomach, 704
Dowd's technic for decortication of lung, 273
Dräger combined apparatus, intrathoracic surgery and, 213
Duct cancer, 169
of Wirsung, relation of, to common bile-duct, 432
Dunham, Theodore, instruments for treatment of cicatricial stricture of esophagus, 73, 74
Duodenal retention, fluoroscopic observation of, 594
Duodenitis, acute pancreatitis and, 447
Duodenum, atresia of, 704
bacteriology of, 704
contour of, fluoroscopic observation of, 594
diverticuli of, 704
examination of, by roentgen plates or films, 598
injuries of, 705
lesions of, diagnosis of, 598
mobility of, 597
spasms of, diagnosis of, 597
stenosis of, 704
in ulcer, 690
surgery of, 763
ulcer of, 686, 763
abdominal tenderness in, 695
acute, 691
pancreatitis and, 447
perforating, 771
age and, 687
anemia in, 690, 694
appetite in, 694
belching of sour gas in, 693
calloused, 691
chronic, 691
constipation in, 694
cutaneous burns and, 764
definition of, 686
diagnosis of, 764
dilated "splashy stomach" in, 695
enlargement of stomach in, 701
eructations in, 693
food-ease of pain in, 692
habits and, 689
hematemesis in, 693
hemorrhage in, 691
incidence of, 686
laboratory examination in, 695
malignant change in, 644

Duodenum, ulcer of, melena in, 693
morbid anatomy of, 689
motor function in, 696
"occult" hemorrhage in, 693
pain in, 692, 763
pain-time in, 692
perforation in, 690, 691
previous disease and, 687
pyrosis in, 693
race and, 687
roentgen evidence in, 697
secondary effects of, 690
sex and, 687
signs of, 694
stenosis of duodenum in, 690
stool in, 697
symptoms of, 691, 763
test-meal in, 695
total acidity in, 696
treatment of, 764
vomiting in, 693, 763
"water-brash" in, 693
weakness in, 694
Durst's method of gastropexy, 742
Dysphagia in ulceration of esophagus, 47
Dyspnea in cysts of spleen, 516
in fractures of ribs, 225

E

Echinococcus cyst of breast, 155
of chest, 251
of chest-wall, 251
of liver, 365
diagnosis of, from cysts of pancreas, 485
symptoms of, 366
treatment of, 367
of lungs, 252
diagnosis of, 252
treatment of, 252
of spleen, 514
Eclampsia, pleural, 238
Eczema of nipple, 144
Edema in carcinoma of pancreas, 496
Egyptian splenomegaly, 548
Einhorn's cardiodilator, 53
Elevation of diaphragm, congenital, 605
Embolism, gas, 236
Embryology of spleen, 503
Emphysema, 236
of lungs, 288
chondrectomy for, 290
dyspnea in, 288
Freund's operation for, 290
symptoms of, 288
treatment of, surgical, 289
subcutaneous, 240
fractures of ribs and, 226
subpleural, 240
Empyema, 259
chronic, extensive resection of thorax in, technic of, 271
decortication of lung for, 272
of gall-bladder, 394
Empyema, metapneumonic, 260
old, Schede's operation for, 270
recent, surgery of, 261
v. Hacker's method of drainage in, 268
thoracotomy with rib resection for, 263
trephining of rib for, 267
traumatic, 259
treatment of, Beck's bismuth paste in, 285
tuberculous, 260
Enchondroma of breast, 173
of chest-wall, 254
Endothelioma of pleura, 255
Enteric intussusception, 806
Enteritis in cancer of stomach, 686
Epiploitis, 792
Epiplopexy, 801
Epistaxis in Gaucher's disease, 532
Eructations in gastric ulcer, 621
in pyloric stenosis, 635
in ulcer of duodenum, 693
Esophageal dilator, Mosher's, 53
extractor, Meyer's, 116
Esophagitis, acute, 45
chronic, 46
Esophagogastrostomy in treatment of spastic stenosis of esophagus, 58
transpleural, 59
Esophagoplasty for carcinoma of esophagus, 85, 117, 119
antithoracic to form a total esophagoplasty, 134
combined, partial, superior, and inferior, 134
extrathoracic, 136
inferior, 129, 131, 132
intrathoracic, 135
by means of skin-plasty, 129
partial, 120
inferior, 120
superior, 128
total, 128
Esophagoscope, Jackson's, 34
Esophagoscopy in diagnosis of diseases of stomach, 574
in examinations of esophagus, 33
Esophagus, abscess of, 46
anatomy of, 18
arteries of, 21
bullet wounds of, 43
carcinoma of, 78
esophagoplasty for, 85, 117, 119
gastrostomy for, 89
occurrence of, 78
posterior mediastinotomy for, 88
resection for, 83, 87
of cardia for, 107
symptoms of, 79
transthoracic operation for, 89
treatment of, 80
non-operative, 81

Esophagus, carcinoma of, treatment of, operative, 82
type of, 78
congenital anomalies of, 49
diagnosis of, 50
treatment of, 50
diverticulum of, pressure, 61
diagnosis of, 63
etiology of, 61
location of, 61
symptoms of, 62
treatment of, 64
pulsion, 61
examination of, 31
esophagoscopy in, 33
fluoroscopy in, 36
newer methods of, 33
older methods of, 31
sounding in, 31
instruments, 31
posture of patient, 31
radiography in, 36
foreign bodies in, 39
hemorrhage into, 45
inflammation of, acute, 45
chronic, 46
tuberculous, 47
injuries of, 242
innervation of, 19
lymphatic glands of, 25
vessels of, 24
nerves of, 26
perforation of, acute, 42
gradual, 45
physiologic points of, 29
sarcoma of, 77
spontaneous rupture of, 44
stenosis of, cicatricial, 67
treatment of, 68
operative, 70
compression, 59
aortic aneurysm and, 60
posterior mediastinal tumor and, 61
tuberculous, specific or malignant peribronchial lymph nodes and, 61
spastic, 50
cardioplasty for, 57
diagnosis of, 57
esophagogastrostomy for, 58
etiology of, 51
treatment of, 52
non-operative, 52
operative, 55
vagolysis combined with esophagoplication for, 56
stricture of, 48
tumors and, 77
surgical pathology of, 39
ulceration of, 46
dysphagia in, 47
pain in, 47
peptic, 47
syphilitic, 47
Esophagus, ulceration of, treatment of, 47
veins of, 23
Eventration of diaphragm, 605
Extrapleural operations for wounds of chest, 319
Eyes in Gaucher's disease, 532

F

Fat necrosis, 451
of cavity of great omentum, 802
Feces, examination of, diagnosis of diseases of stomach and, 589
Fever in abscess of liver, 373
in acute pancreatitis, 453
in splenic anemia, 524
Fibro-adenoma of breast, 165
Fibrocystadenoma of breast, 171
Fibro-epithelial tumors of breast, 165
Fibroma of breast, cystic, 165
intracanalicular, 165
of omentum, 794
periductal, 165
Fibromyxoma of breast, 165
Fibrosarcoma of pleura, 255
Fibrous cancer of stomach, 662
Finney's operation for pyloroplasty, 748
Fissures of nipple, 144
Fistula, biliary, 407
in cancer of stomach, 686
rupture of pancreas and, 441
Fistulæ of pleura, treatment of, Beck's bismuth paste in, 285
pulmonary, 284
Fluoroscopic examination, diagnosis of diseases of stomach and, 593
in diaphragmatic hernia, 607
in gastroptosis, 610
motor-meal, information derived from observation of, 593
observation of contour of duodenum, 594
of stomach, 594
of duodenal retention, 594
of opaque meal, 594
Fluoroscopy in examination of esophagus, 36
Foci of infection in gastric ulcer, 624
"Food-ease" of pain in ulcer of duodenum, 692
Foreign bodies in breast, 143
in bronchi, 277
bronchoscopy for, 278
mediastinal bronchotomy for, 280
in esophagus, 39
in lung, 277
extraction of, 281
removal of, pneumobronchotomy for, 279
results of, 279
thoracotomy for, 278
in stomach, 706
diagnosis of, from cancer, 685

Foreign bodies in stomach, treatment of, 706
Fractures of costal cartilages, 227
kyphosis following, 202
of ribs, 223
complications of, 226
diagnosis of, 226
dyspnea in, 225
external, 224
internal, 224
pain in, 225
pneumothorax and, 226
subcutaneous emphysema and, 226
symptoms of, 225
traumatic aneurysm and, 226
treatment of, 227
of sternum, 228
cross-shaped, 229
diagnosis of, 230
transverse, 229
treatment of, 230
"Free" hydrochloric acidity, diagnosis of diseases of stomach and, 680
Freund's chondrotomy in congenital, rigid and dilated thorax, 291
decompression operation in treatment of pulmonary tuberculosis, 310
Friedrich's large flap operation in treatment of pulmonary tuberculosis, 304
rib spreader, 90
Fuld and Levison test for edestin in gastric extracts, 583
Functional diseases of breast, 146
Funnel-chest, 207
Furuncles of chest-wall, 240

G

Galactocele, 157
Gall-bladder, anatomy of, 385
carcinoma of, 408
symptoms of, 410
treatment of, 410
congenital anomalies of, 389
diseases of, diagnosis of, from cancer of stomach, 681
enlarged, diagnosis of, from cysts of pancreas, 485
empyema of, 394
function of, 388
inflammation of, 393
operations on, 410
perforations of, 391
rupture of, 391
prognosis of, 392
symptoms of, 391
treatment of, 393
surgical diseases of, 393
etiology of, 398
wounds of, 391
Gall-stones, 398. *See* also Cholelithiasis.
complications of, 400
Gall-stones, diagnosis of, *x*-rays in, 404
etiology of, 398
intrahepatic, 404
pathogenesis of, 399
prognosis of, 405
treatment of, 406
Gangrene of lung in wounds of chest, 326
pulmonary, 274
diagnosis of, 274
prognosis of, 276
resection of lung in, 275
treatment of, 275
Gangrenous pancreatitis, 452
Gas embolism, 236
Gastrectomy, 745
for cancer of stomach, 710, 711, 718
for cirrhosis of stomach, 707
Gastric acidity, 579
in cancer of stomach, 672
diagnosis of diseases of stomach and, 579
in syphilis of stomach, 655
tests for, 580
adhesions, operations for, 749
emptying power, diagnosis of diseases of stomach and, 575
investigation of, 575
physiological motor meal and, 575
size of stomach and, 576
retarded, 578
extracts, acidity of, in gastric ulcer, 625
macroscopic appearance of, diagnosis of diseases of stomach and, 576
microörganisms in, diagnosis of diseases of stomach and, 585
in syphilis of stomach, 655
granuloma, diagnosis of, from cancer of stomach, 685
hemorrhage, 612
etiology of, 612
morbid anatomy of, 613
"occult," 613
prognosis of, 616
signs of, 614
symptoms of, 614
malfunction, diagnosis of diseases of stomach and, 561
in syphilis of stomach, 651
orifices, estimation of patency of, in diagnosis of diseases of stomach, 593
ulcer, 616
abdominal tenderness in, 622
acidity of gastric extracts in, 625
adhesions in, 632
age and, 616
appetite in, 621
blood in, 624
cancer and, 640, 661

Gastric ulcer, complications of, 631
constipation in, 621
course of, 640
diarrhea in, 621
dilated "splashy stomach" in, 623
eructations in, 621
etiology of, 616
excision of, 746
foci of infection in, 624
frequency of transition of, to cancer, 642
gastro-enterostomy as protection against malignant transition of, 645
habits and, 617
headache in, 622
hemorrhage in, 620, 632
hour-glass contraction in, 631
infectious diseases and, 617
laboratory examination in, 624
location of, 617
malaise in, 622
malignant change in, 642
metamorphosis in, 631
melena in, 621
morbid anatomy of, 617
nationality and, 616
nature of, 640
nutrition in, 622
occupation and, 616
pain in, 618
perforation in, 632
peristalsis in, 623
physical examination in, 622
pyloric obstruction in, 631
pyrosis in, 621
sex and, 616
signs of, 622
stools in, 625
symptoms of, 618
symptom-complex of, clinical variations in, 644
test-meal in, 624
vomiting in, 620
weakness in, 622
x-ray examination in, 626
Gastro-enterostomy, 751
anterior, 752
for cancer of stomach, 709
intestinal obstruction following, 761
peptic ulcer complicating, 761
posterior, 754
as protection against malignant transition of gastric ulcer, 645
pyloric exclusion in, 760
Roux's operation, 758
vicious circle complicating, 760
Gastro-esophagostomy for cancer of stomach, 710, 719
Gastro-intestinal function, examination of, 575
Gastrojejunostomy, 752
Gastropexy, 742
Beyer's method of, 743
Coffey's method of, 743
Gastropexy, Durst's method of, 742
Rovsing's method of, 743
Gastroplication, 742
Gastroptosis, 608
appetite in, 609
constipation in, 609
fluoroscopic examination in, 610
malnutrition in, 609
nausea in, 608
signs of, 609
symptoms of, 608
vomiting in, 608
x-ray examination in, 609
Gastrorrhagia, 612
etiology of, 612
morbid anatomy of, 613
"occult," 613
chemical tests for, 615
prognosis of, 616
signs of, 614
symptoms of, 614
Gastroscopy in cancer of stomach, 679
in diagnosis of diseases of stomach, 574
Gastrostomy, 735
for cancer of stomach, 711
for carcinoma of esophagus, 89
Janeway method of, 741
Kader's method of, 735
Senn's method of, 735
Ssbanajew-Franck method of, 739
Witzel method of, 736
Gastrotomy, 134
Gaucher's disease, 529
blood in, 532
diagnosis of, 532
from splenic anemia, 526
epistaxis in, 532
etiology of, 529
eyes in, 532
familial occurrence of, 531
hemorrhages in, 532
incidence of, 531
liver in, 531
lymphatic glands in, 532
pathology of, 530
sex and, 531
skin in, 532
splenectomy in, 533
splenic enlargement in, 531
symptoms of, 531
treatment of, 533
Gelatinous cancer of stomach, 662
Glycosuria in carcinoma of pancreas, 496
in chronic pancreatitis, 472
in pancreatic calculi, 490
Glycyltryptophan test for specific ferments in gastric extracts, 585
Great omentum, abscess of, 792
diagnosis of, 792
treatment of, 793
absorption power of, 791
anatomy of, 789
carcinoma of, 795
cavity of, abscess of, 802
cysts of, pancreatic, 802

Great omentum, cavity of, cysts of, sanguineous, 802
fat necrosis of, 802
hernia of, 802
pseudocysts of, 802
cystic lymphangioma of, 794
sarcoma of, 796
fibroma of, 794
functions of, 790
histology of, 790
inflammatory disorders of, 792
lipoma of, 793
mechanics of, 790
movements of, 790
neoplasms of, 793
diagnosis of, 796
symptoms of, 796
treatment of, operative, 797
parasitic cysts of, 796
phagocytic role of, 791
physiology of, 789
sarcoma of, 794
simple retention cysts of, 794
teratoma of, 796
torsion of, 797
treatment of, 800
Gunshot wounds of pancreas, 439
Gutter-chest, 201
Gynecomazia, 142

H

v. Hacker's method of drainage for empyema, 268
introducing bougies in cicatricial stenosis of esophagus, 70
Hanot's cirrhosis, diagnosis of, from splenic anemia, 526
Heart in cholelithiasis, 403
surgery of, 331
wounds of, 339
Heineke-Mikulicz operation for pyloroplasty, 748
Hematemesis, 612, 614. *See* Gastric hemorrhage.
in splenic anemia, 523
in ulcer of duodenum, 693
Hematoma of breast, 143
Hemolysis in pernicious anemia, 543
Hemolytic jaundice, congenital and acquired, 533
diagnosis of, 537
from splenic anemia, 526
etiology of, 533
jaundice in, 535
pathology of, 534
prognosis of, 538
splenomegaly in, 536
symptoms of, 534
treatment of, 538
urobilinuria in, 537
Hemoptysis in penetrating wounds of chest, 315
Hemorrhage in cancer of stomach, 669
Hemorrhage, diagnosis of diseases of stomach and, 565
in esophagus, 45
from stomach, 724
treatment of, 724
from thorax, traumatic, 236
in gastric ulcer, 620
in Gaucher's disease, 532
in injuries of liver, 362
in pyloric stenosis, 635
in rupture of pancreas, 440
of stomach in gastric ulcer, 632
in ulcer of duodenum, 691
in wounds of liver, 363
Hemorrhagic cysts of spleen, 515
pancreatitis, 449
Hepatic artery, aneurysm of, 384
symptoms of, 384
treatment of, 385
Hepatoptosis, 359
symptoms of, 360
treatment of, 360
Hernia of cavity of great omentum, 802
diaphragmatic, 235
acquired, 607
clinical history in, 607
fluoroscopic examination in, 607
Litten's sign in, 607
physical signs in, 607
congenital, 606
prognosis of, 235
treatment of, 235
of lung, 282
spontaneous, 282
treatment of, 284
traumatic, 282
treatment of, 283
Hodgkin's disease, splenic anemia and, 522
Hour-glass contractions in gastric ulcer, 631
stomach, 726
in cancer, 686
Hültl's wire stitching instrument, 126
Hygroma, retroperitoneal, diagnosis of, from cysts of pancreas, 485
Hyperperistalsis, diagnosis of diseases of stomach and, 597
Hypertrophic pyloric stenosis, congenital, 600, 773
peristalsis in, 779
symptoms of, 778
treatment of, 780
tumor in, 779
urine in, 779
vomiting in, 778
of infants, 773
Hypertrophy of breast, diffuse, 147
diagnosis of, 148
prognosis of, 148
senile parenchymatous, 157
treatment of, 148
of stomach, 703
Hysterical breast, 146

I

Ileocecal intussusception, 806
Ileus, 803. *See* Intestine, small, obstruction of.
paralytic, 833
diagnosis of, 835
etiology of, 834
pathology of, 834
symptoms of, 835
treatment of, 836
spastic, 833
Imperforate nipple, 144
Indurative mediastinopericarditis, 351
Infantile hypertrophy of breast, 148
Inflammation of bile-ducts, 393
of esophagus, acute, 45
chronic, 46
of gall-bladder, 393
of pancreas, 442
Inflammatory diseases of breast, 149, 153
Intercostal arteries, hemorrhages from, 236
Internal mammary artery, hemorrhages from, 236
Intestinal obstruction, gastro-enterostomy and, 763
Intestine, large, tumors of, diagnosis of, from cancer of stomach, 685
small, obstruction of, 803
collapse in, 818
diagnosis of, 822
distention in, 818
mechanical, causes of, 804
nausea in, 818
pain in, 818
pathology of, 820
symptoms of, 818
treatment of, 828
vomiting in, 818
Intracanalicular papillary fibroma of breast, 165
Intrahepatic gall-stones, 404
Intrathoracic operations for wounds of chest, 325
surgery, 204
anesthesia in, 208
anoci-association in, 209
antisepsis in, 208
asepsis in, 208
before cavity of chest is opened, 206
blood-pressure and, 206
Dräger combined apparatus and, 223
general principles of, 204
intratracheal insufflation in, 216
overpressure apparatus in, 213
pleural adhesion in, diagnosis of degree of, 209
position of patient in, 207
preparation of patient in, 206
pressure differences in, 211
apparatus for, 217
present status of, 217
procedures in, 217
Intrathoracic surgery, respiration in, 211
underpressure procedure in, 212
Willy Meyer cabinet and, 216
Zürich cabinet and, 212
Intussusception, 806
enteric, 806
ileocecal, 807
Inversion of nipple, 143
Irritable mamma, 146
Islands of Langerhans, 438

J

Jackson's esophagoscope, 34
von Jaksch's disease, 528
Janeway method of gastrostomy, 741
Jaundice in acute pancreatitis, 448, 454
in cancer of stomach, 686
in carcinoma of liver, 380
of pancreas, 495
in cholelithiasis, 403
in chronic pancreatitis, 470
hemolytic, congenital and acquired, 533
blood in, 536
diagnosis of, 537
from splenic anemia, 526
etiology of, 533
jaundice in, 535
pathology of, 534
prognosis of, 538
splenomegaly in, 536
symptoms of, 534
treatment of, 538
urobilinuria in, 537
in injuries of liver, 363
in wounds of liver, 363
Jejunostomy for cancer of stomach, 711

K

Kader's method of gastrostomy, 735
Kala-azar, 549
Kenyon's method of draining pleural cavity, 104, 105
Kidney, cysts of, diagnosis of, from cysts of pancreas, 486
left, diseases of, diagnosis of, from splenic anemia, 526
tumors of, diagnosis of, from cancer of stomach, 685
from cysts of pancreas, 486
Kyphosis, 202
angular, 202
following fractures, 202
heredo-traumatic form of, 202

L

Lactic acid, diagnosis of diseases of stomach and, 580
Langerhans, islands of, 438

Lateral curvature of spine, 202
Leukemia, splenomedullary, 145
Leukocytosis in abscess of liver, 373
in acute pancreatitis, 454
in carcinoma of liver, 380
Ligation of branches of pulmonary artery for artificial production of atrophy of lung in treatment of pulmonary tuberculosis, 309
Linitis plastica, 707
gastrectomy for, 707
x-rays in diagnosis of, 707
Lipoma of breast, 173
of omentum, 793
retroperitoneal, diagnosis of, from cysts of pancreas, 485
Litten's sign in diaphragmatic hernia, 607
Liver, abscess of, 372
complications of, 374
diagnosis of, *x*-rays in, 375
fever in, 373
leukocytosis in, 373
Muhlman's operation in, 375
pain in, 373
symptoms of, 373
treatment of, 375
actinomycosis of, 376
anatomy of, 357
angioma of, 377
carcinoma of, 377
secondary, 380
diagnosis of, 380
jaundice in, 380
leukocytosis in, 380
resection in, 380
symptoms of, 380
treatment of, 377
cirrhosis of, 369
diagnosis of, from splenic anemia, 526
pathology of, 369
treatment of, 370
diseases of, 364
displacements of, 359
symptoms of, 360
treatment of, 360
echinococcus cysts of, 365
diagnosis of, 366
from cysts of pancreas, 485
symptoms of, 366
treatment of, 367
in Gaucher's disease, 531
injuries of, 361
subcutaneous, 361
bradycardia in, 362
hemorrhage in, 362
jaundice in, 363
pain in, 362
symptoms of, 362
operations on, 410
anesthesia in, 411
incision in, 413
instruments for, 412
position of patient in, 413
sarcoma of, primary, 379
Liver, syphilis of, 364
tuberculosis of, 367
diagnosis of, 368
prognosis of, 368
treatment of, 368
tumors of, 377
diagnosis of, from cysts of pancreas, 485
wounds of, gunshot, 363
hemorrhage in, 363
jaundice in, 363
shell, 363
treatment of, 364
Lues, diagnosis of, from cancer of stomach, 685
Luetic lesions in syphilis of stomach, 651
Lung, abscess of, 274
carcinoma of, primary, 256
diagnosis of, 257
symptoms of, 257
collapse of, in wounds of chest, 316
cysts of, echinococcus, 252
diagnosis of, 252
treatment of, 252
decortication of, for empyema, 272
Dowd's technic of, 273
emphysema of, 288
chondrectomy in, 290
dyspnea in, 288
Freund's operation for, 290
symptoms of, 288
treatment of, surgical, 289
fistulæ of, 284
diagnosis of, 285
treatment of, Beck's bismuth paste in, 285
foreign bodies in, 277
extraction of, 281
removal of, pneumobronchotomy for, 279
results of, 279
gangrene of, 274
in wounds of chest, 326
hernia of, 282
spontaneous, 282
treatment of, 284
traumatic, 282
treatment of, 283
infections of, 273
lymphosarcoma of, primary, 257
resection of, in pulmonary abscess, 275
gangrene, 275
sarcoma of, primary, 257
sclerosis of, local, 277
suppurations of, 273
tumors of, malignant, 255
diagnosis of, 256
secondary, 258
serotherapy in, 258
treatment of, 256
Luschka's deformity of ribs, 201
Lymphangioma of omentum, cystic, 794
Lymphatic cysts of spleen, 515
glands in Gaucher's disease, 532
Lymphatics of spleen, 503

Lymphoma, diagnosis of, from splenic anemia, 526
Lymphosarcoma of lung, 257

M

Malaise in gastric ulcer, 622
Malaria, cancer of stomach and, 661
Malarial spleen, 547
Malformations of breast, 141
of male breast, 196
Mamma, irritable, 146
treatment of, 146
Mastitis, acute, 149
cancerous, 179
chronic, 155
cystic, 157
diagnosis of, 156
of mumps, 323
neonatorum, 149
of puberty, 150
puerperal, 150
milk engorgement and, 150
Mastodynia, 146
treatment of, 146
Mayo's transgastric resection for gastric ulcers, 747
Meckel's diverticulum, 805
Mediastinal bronchotomy for foreign bodies in bronchi, 280
Mediastinitis, subacute posterior suppurative, 46
Mediastinopericarditis, indurative, 351
Mediastinotomy, posterior, for carcinoma of esophagus, 89
Mediastinum, posterior, tumors of, compression stenosis of esophagus and, 61
Medullary cancer of stomach, 662
Melena, 612, 614. *See* Gastric hemorrhage.
in ulcer of duodenum, 693
Mesentery, cysts of, diagnosis of, from cysts of pancreas, 485
Metapneumonia empyema, 260
Metastases, diagnosis of diseases of stomach and, 572
Meteorism in acute pancreatitis, 454
Meyer's cabinet in intrathoracic surgery, 216
esophageal extractor, 90, 116
operating table for thoracic operations, 93
Micromastia, 141
Micromazia, 141
Mosher's esophageal dilator, 53
Motor-meal, fluoroscopic, information derived from observation of, 593
Mucoid cancer of stomach, 662
Muhlman's operation in abscess of liver, 375
Mumps, acute pancreatitis and, 447
mastitis of, 153
Murphy's technic for artificial pneumothorax, 297
Myxoma, periductal, 167
Myxoma of stomach, 707
Myxosarcoma, periductal, 167
of pleura, 255

N

Nausea in acute pancreatitis, 448
in chronic pancreatitis, 470
diagnosis of diseases of stomach and, 564
in gastroptosis, 608
in ileus, 820
in wandering spleen, 512
Necrosis, fat, 451
Neoplasms of omentum, 793
of pancreas, cystic, 476
of ribs, 253
Nerves of spleen, 503
Neuralgia of breast, 146
Nipple, cracks of, 144
depression of, 143
eczema of, 144
fissures of, 144
imperforate, 144
inversion of, 143
Paget's disease of, 144
diagnosis of, 145
pathology of, 145
prognosis of, 145
treatment of, 145
retraction of, 143
tumors of, 145
Non-parasitic cysts of spleen, 514
Non-penetrating wounds of thorax, 230
Non-suppurative pancreatitis, 447
Nutrition in gastric ulcer, 622

O

Obesity, acute pancreatitis and, 455
Obstruction of stomach, 725
"Occult" blood, diagnosis of diseases of stomach and, 580, 591
gastrorrhagia, 613
hemorrhage in ulcer of duodenum, 693
Omentitis, 792
diagnosis of, 792
Omentopexy, 801
Omentovolvulus, 797
paracolic, 798
parasaccular, 798
resected, 799
Omentum. *See* Great omentum.
tumors of, diagnosis of, from cancer of stomach, 685
from cysts of pancreas, 486
Opaque meals, fluoroscopic observation of, 594
Osteochondritis, typhoid, 247
Osteoma of breast, 173
Osteomyelitis, 247
Osteoperiosteitis of ribs, 247
of sternum, 247
typhoid, 247

P

Paget's disease of nipple, 144
Pain in abscess of liver, 373
in acute cholecystitis, 401
pancreatitis, 448, 453
in carcinoma of pancreas, 495
in cholelithiasis, 403
in chronic pancreatitis, 470
in cysts of pancreas, 482
of spleen, 515
diagnosis of disease of stomach and, 562
in fractures of ribs, 225
in gastric ulcer, 618
in ileus, 818
in injuries of liver, 362
in pancreatic calculi, 489
in pyloric stenosis, 636
in infancy, 601
in rupture of pancreas, 440
in splenic anemia, 523
in tumors of spleen, 514
in ulcer of duodenum, 692, 763
of esophagus, 47
in wandering spleen, 512
Pain-time in ulcer of duodenum, 692
Pancreas, abnormalities of, 437
abscess of, diagnosis of, from cysts, 485
accessory, 437
anatomy of, 427
annular, 437
blood supply of, 428
carcinoma of, 494
ascites in, 496
diagnosis of, 494
edema in, 496
extirpation in, 497
glycosuria in, 496
jaundice in, 495
pain in, 495
symptoms of, 494
treatment of, 497
operative, 499
concretions of, 488. *See* Pancreatic calculi.
congenital malformations of, cysts and, 476
cystadenomas of, 476, 493
cysts of, 475
congenital malformations and, 476
diagnosis of, 480
from abscess of abdominal wall, 483
of pancreas, 485
from aneurysm of abdominal aorta, 483
from cysts of kidney, 485
of mesentery, 485
of round ligament, 485
of spleen, 485
from echinococcus cyst of liver, 483
Pancreas, cysts of, diagnosis of, from enlarged gall-bladder, 485
from retroperitoneal hygroma, 485
lipoma, 485
tuberculosis, 486
from tumors of kidney, 486
of liver, 483
of omentum, 486
of peritoneum, 486
of vertebral column, 486
x-ray in, 482
drainage in, 488
exudative, of omental sac, 478
pain in, 480
proliferative, 476
retention, 476
by self-digestion, 477
situation of, 478
size of, 478
by softening, 477
symptoms of, 480
true, 476
treatment of, 486
head of, relation of, to common bile duct, 432
inflammation of, 442
injuries of, 439
lymphatics of, 429
pathological physiology of, 434
physiology of, 433
pseudocysts of, 477
rupture of, subcutaneous, 440
fistula and, 441
hemorrhage in, 440
pain, 440
prognosis of, 440
symptoms of, 440
treatment of, 440
vomiting in, 440
syphilis of, 493
tuberculosis of, 493
tumors of, 493
wounds of, 439
Pancreatic apoplexy, 449
calculi, 488
diagnosis of, 490
x-rays in, 490
etiology of, 489
glycosuria in, 490
pain in, 489
symptoms of, 489
treatment of, 491
vomiting in, 489
cysts of cavity of great omentum, 802
ducts, anatomy of, 430
Pancreatitis, acute, 447
alcoholism and, 455
arteriosclerosis and, 455
chicken-pox and, 447
cholecystitis and, 447
cholelithiasis and, 447
cyanosis in, 453

Pancreatitis, acute, diagnosis of, 453
from syphilis, 456
diphtheria and, 447
drainage in, 462
duodenal ulcer and, 447
duodenitis and, 447
fever in, 453
jaundice in, 448, 454
leukocytosis in, 454
meteorism in, 454
mumps and, 447
nausea in, 448
obesity and, 455
pain in, 448, 453
pregnancy and, 455
pulse in, 453
scarlet fever and, 447
symptoms of, 453
treatment of, 456
vomiting in, 448, 453
chronic, 463
constipation in, 470
diagnosis of, 468
differential, 473
diarrhea in, 470
drainage in, 474
glycosuria in, 472
jaundice in, 470
nausea in, 470
pain in, 470
symptoms of, 468
treatment of, 473
urine in, 472
vomiting in, 469
gangrenous, 452
hemorrhagic, 447
simple non-suppurative, 447
suppurative, 448, 452
Papillary cystadenoma of breast, 169
diagnosis of, 171
treatment of, 171
fibroma of breast, intracanalicular, 165
Papilloma of breast, villous, 169
of stomach, 707
Paracolic omentovolvulus, 798
Paralytic ileus, 833
diagnosis of, 835
etiology of, 834
pathology of, 834
symptoms of, 835
treatment of, 836
Parasaccular omentovolvulus, 798
Parasitic cysts of omentum, 796
Parenchymatous hypertrophy of breast, senile, 157
Penetrating wounds of pancreas, 439
of spleen, 509
Peptic index for specific ferments in gastric extracts, 584
ulcers of esophagus, 47
gastro-enterostomy and, 762
Perforation of esophagus, acute, 42, 45
of stomach in gastric ulcer, 632
Pericarditis, acute, 351
Pericardium, drainage of, 350
Pericardium, tumors of, 352
wounds of, 340
Periductal fibroma, 165
myxoma, 167
myxosarcoma, 167
sarcoma, 167
Peripleuritis, 249
Peristalsis, diagnosis of diseases of stomach and, 597
in gastric ulcer, 623
in pyloric stenosis, 636
Peritoneum, tumors of, diagnosis of, from cysts of pancreas, 486
Pernicious anemia, 539
blood in, 543
diagnosis of, 540
from splenic anemia, 525
etiology of, 539
hemolysis in, 543
pathology of, 540
splenectomy in, 544
transfusion of blood in, 542
treatment of, 541
Phlegmon of chest-wall, 242
Physiological motor meal, 575
Pigeon-breast, 201
Pleomastia, 141
Pleura, carcinoma of, secondary, 255
endothelioma of, 255
fibrosarcoma of, 255
fistulæ of, treatment of, Beck's bismuth paste in 285
myxosarcoma of, 255
sarcoma of, 255
surgical diseases of, 258
tumors of, malignant, 254
Pleural adhesions, diagnosis of degree of, in intrathoracic surgery, 209
eclampsia, 238
symptoms of, 239
reflexes, 236
Pleurisy, purulent, 259
Pleuritic scar contraction, 204
Plummer's double olive bougie, 68
hydrostatic cardiodilator, 53
Pneumectomy in treatment of pulmonary tuberculosis, 294
Pneumobronchotomy for removal of foreign bodies from lung, 279
Pneumolysis interpleuralis in treatment of pulmonary tuberculosis, 308
Pneumothorax, artificial, 294
contra-indications for, 295
indications for, 295
Murphy's technic for, 297
fracture of ribs and, 226
surgical, 232
traumatic, 230
in wounds of chest, 316
Pneumotomy in treatment of bronchiectasis, 287
Polymastia, 141
Polymazia, 141
Polythelia, 141
Pott's disease of spine, 202
Precardial thoracostomy, 352

Pregnancy, acute pancreatitis and, 455
Presternal cyst congenital, 253
Pressure diverticulum of esophagus, 61
Prolapse of spleen, 509
Pseudocysts of cavity of great omentum, 802
of pancreas, 476
Puberty, mastitis of, 150
Puerperal mastitis, 150
milk engorgement and, 150
Pulmonary abscess, 274
chronic simple bronchiectasis and, 276
diagnosis of, 274
prognosis of, 276
putrid, bronchiectasis and, 277
resection of lung in, 275
treatment of, 275
fistulæ, 284
diagnosis of, 285
treatment of, Beck's bismuth paste in, 285
gangrene, 274
diagnosis of, 274
prognosis of, 276
resection of lung in, 275
treatment of, 275
tuberculosis, artificial pneumothorax in, 294
chondrotomy for, 310
drainage in, 293
extrapleural thoracoplasty for, 299
Friedrich's large flap operation for, 304
grafting in, 298
incision in, 293
ligation of branches of pulmonary artery for artificial production of atrophy of lung in treatment of, 309
pneumectomy in, 294
pneumolysis for, 298
surgery of, 291
outline of original effort in, 291
Tuffier's operation in treatment of, 298
Wilm's operation of columnar resection of ribs to narrow thorax in treatment of, 307
Pulsion diverticulum of esophagus, 61
Purulent pleurisy, 259
Pylorectomy for cancer of stomach, 711
Pyloric canal, anatomy of, 775
pathological anatomy of, 775
obstruction in cancer of stomach, 685
in gastric ulcer, 631
spasm, diagnosis of, from pyloric stenosis in infancy, 603
stenosis, 725
benign, 633
abdominal palpation in, 636
causation of, 633
Pyloric stenosis, benign, effects of, 633
eructations in, 635
hemorrhage in, 635
incidence of, 633
motor-meal in, 638
observation-meal in, 639
pain in, 636
peristalsis in, 636
pyrosis in, 635
regurgitation in, 635
secretory meal in, 638
signs of, 636
"splash stomach" in, 637
symptoms of, 634
test-meal in, 637
vomiting in, 634
"water brash" in, 635
x-ray examination in, 638
congenital, 725
hypertrophic, 600, 773
peristalsis in, 779
symptoms of, 778
treatment of, 780
tumor in, 779
urine in, 779
vomiting in, 778
in infancy, 600
abdominal tumor in, 602
age and, 600
carmin test in, 602
constipation in, 601
definition of, 600
diagnosis of, 602
from pyloric spasm, 603
etiology of, 600
genesis of, 600
loss of weight in, 602
pain in, 601
pathology of, 601
prognosis of, 603
roentgen examination in, 602
signs of, 602
symptoms of, 601
urine in, 601
Pylorodiosis, 748
Pyloroplasty, 748
Finney's operation, 748
Heineke-Mikulicz operation, 748
Pyrosis in gastric ulcer, 621
in pyloric stenosis, 635
in ulcer of duodenum, 693

R

Rachitis, chicken-breast and, 201
Radiography in examination of esophagus, 36
Radium in carcinoma of breast, 186
Rectal examination, diagnosis of diseases of stomach and, 572
Regurgitation in pyloric stenosis, 635
Renal complications in splenic anemia, 524
Resected omentovolvulus, 799

Resection for carcinoma of esophagus, 83, 87
of cardia for carcinoma of esophagus 107
of lung in pulmonary abscess, 275
gangrene, 275
of thorax for empyema, 271
Respiration, intrathoracic surgery and, 211
Retention cysts of omentum, 796
Retraction of nipple, 143
Retroduodenal, choledochotomy, 420
Retroperitoneal hygroma, diagnosis of, from cysts of pancreas, 485
lipoma, diagnosis of, from cysts of pancreas, 485
tuberculosis, diagnosis of, from cysts of pancreas, 486
Rheumatism, cancer of stomach and, 661
Rib, trephining of, for empyema, 267
Ribs, deformities of, congenital, 199
Cruveilhier's, 201
Luschka's, 201
Serb's, 201
dislocations of, 228
fractures of, 223
complications of, 226
diagnosis of, 226
dyspnea in, 225
external, 224
internal, 224
pain in, 225
pneumothorax and, 226
subcutaneous emphysema and, 226
symptoms of, 225
traumatic aneurysm and, 226
treatment of, 227
neoplasms of, 253
symptoms of, 254
osteoperiosteitis of, 247
diagnosis of, 247
treatment of, 247
sarcoma of, 254
tuberculosis of, 248
diagnosis of, 248
prognosis of, 249
treatment of, 249
Rigid spine, 203
thorax, treatment of, chondrotomy in, 291
Rodman's operation for gastric ulcers, 747
Roentgen examination in cancer of stomach, 679
diagnosis of diseases of stomach and, 592
in pyloric stenosis in infancy, 602
in ulcer of duodenum, 697
plates, examination of duodenum by, 598
of stomach by, 598
interpretation of, in diagnosis of diseases of stomach, 599
Round ligament, diagnosis of, from cysts of pancreas, 485
Rovsing's method of gastropexy, 743
Rupture of esophagus, spontaneous, 44
of gall-bladder, 391
of pancreas, 440
of spleen, spontaneous, 510
subcutaneous, 509
of stomach, 705

S

Sanguineous cysts of cavity of great omentum, 802
Sarcoma of breast, 173
cystic, 167
of chest-wall, 254
treatment of, 254
of esophagus, 77
of liver, primary, 379
of lung, 257
of omentum, 794
cystic, 796
periductal, 167
of pleura, 255
of ribs, 254
of stomach, 707
Sauerbruck's operation for extrapleural thoracoplasty in treatment of pulmonary tuberculosis, 299
Scarlet fever, acute pancreatitis and, 447
Schede's operation for empyema, 270
Schwartz's mediastinal bronchotomy for foreign bodies in bronchi, 280
Scirrhous cancer of stomach, 662
Sclerosis of lung, local, 277
Scoliosis, 202
Serb's deformity of ribs, 201
Serotherapy in treatment of malignant tumors of lung, 258
Serous cysts of spleen, 515
Skin in Gaucher's disease, 532
Sounding in examination of esophagus, 31
Spasms of duodenum, diagnosis of, 597
pyloric, diagnosis of, from pyloric stenosis in infancy, 603
of stomach, diagnosis of, 596
Spastic hypertrophic pyloric stenosis, 773
ileus, 833
stenosis of esophagus, 50
cardioplasty for, 57
diagnosis of, 51
esophagogastrostomy for, 58
etiology of, 51
treatment of, 52
Spine, lateral curvature of, 202
Pott's disease of, 202
rigid, 203
"Splash stomach" in pyloric stenosis, 607
Spleen, abscess of, 517
diagnosis of, 518
pathology of, 517
prognosis of, 518

Spleen, abscess of, symptoms of, 518
treatment of, 518
anatomy of, 501
angioma of, 516
diagnosis of, 517
treatment of, 517
blood supply of, 503
cysts of, 514
diagnosis of, 516
from cysts of pancreas, 485
dyspnea in, 516
echinococcus, 514
lymphatic, 515
hemorrhagic, 515
non-parasitic, 514
pain in, 515
serous, 515
symptoms of, 515
treatment of, 516
embryology of, 503
enlargement of, in Gaucher's disease, 531
functions of, 506
injuries of, 509
lymphatics of, 503
malarial, 547
nerves of, 503
physiology of, 504
prolapse of, 509
rupture of, spontaneous, 510
diagnosis of, 511
symptoms of, 510
treatment of, 511
subcutaneous, 509
tuberculosis of, 518
pathology of, 519
symptoms of, 519
treatment of, 520
tumors of, 513
diagnosis of, 514
pain in, 514
symptoms of, 514
wandering, 511
diagnosis of, 513
etiology of, 511
nausea in, 512
pain in, 512
pathology of, 512
symptoms of, 512
treatment of, 513
vomiting in, 512
wounds of, penetrating, 509
Splenectomy, Bevan incision in, 550
Splenic anemia, 520
abdomen in, 523
adult type of, in children, 527
anemia in, 524
ascites in, 524
cardiac symptoms in, 524
cholelithiasis and, 521
diagnosis of, 525
digestive disturbances in, 524
etiology of, 521
fever in, 524
hematemesis in, 523
Hodgkin's disease and, 522
Splenic anemia, incidence of, 522
of infancy, 528
pain in, 523
pathology of, 522
renal complications in, 524
splenectomy in, 527
symptoms of, 523
treatment of, 526
Splenomedullary leukemia, 545
Splenomegalia, large cell, 529
blood in, 532
diagnosis of, 532
epistaxis in, 532
etiology of, 529
eyes in, 532
familial occurrence of, 531
hemorrhages in, 532
incidence of, 531
liver in, 531
lymphatic glands in, 532
pathology of, 530
sex and, 531
skin in, 532
splenectomy in, 533
splenic enlargement in, 531
symptoms of, 531
treatment of, 533
Splenomegaly and anemia, syphilis and, 546
Egyptian, 548
in hemolytic jaundice, 536
Spontaneous rupture of spleen, 510
Ssbanajew-Franck method of gastrostomy, 739
Stenosis, congenital hypertrophic pyloric, 773
peristalsis in, 779
symptoms of, 778
treatment of, 780
tumor in, 779
urine in, 779
vomiting in, 778
of duodenum, 704
in ulcer, 690
of esophagus, cicatricial, 67
treatment of, 68
compression, 59
aortic aneurysms and, 60
posterior mediastinal tumor and, 61
tuberculous, specific or malignant peribronchial lymph nodes and, 61
spastic, 50
cardioplasty for, 57
diagnosis of, 51
esophagogastrostomy for, 58
etiology of, 51
treatment of, 52
pyloric, 600, 725
benign, 633
abdominal palpation in, 636
causation of, 633
effects of, 633

Stenosis, pyloric, benign, eructations in, 635
hemorrhage in, 635
incidence of, 633
motor-meal in, 638
observation-meal in, 639
pain in, 636
peristalsis in, 636
pyrosis in, 635
regurgitation in, 635
secretory-meal in, 638
signs of, 636
"splash stomach" in, 637
symptoms of, 634
test-meal in, 637
vomiting in, 634
"water brash" in, 635
x-ray examination in, 638
in infancy, 600
abdominal tumor in, 602
carmin test in, 602
constipation in, 601
definition of, 600
diagnosis of, 602
etiology of, 600
genesis of, 600
loss of weight in, 602
pain in, 601
pathology of, 601
prognosis of, 603
roentgen examination in, 602
signs of, 602
symptoms of, 601
urine in, 601
Sternum, fracture of, 228
cross-shaped, 229
diagnosis of, 230
transverse, 229
treatment of, 230
osteoperiosteitis of, 247
diagnosis of, 247
treatment of, 247
Stomach, adenocarcinoma of, 662
adhesion of, operation for, 743
atresia of, 599
prognosis of, 600
symptoms of, 600
atrophy of, 703
bacteriology of, 704
cancer of, 658, 708
abdominal tumor in, 671
blood in, 674
cachexia in, 671
changes in stomach produced by, 664
colloid, 662
complications of, 685
course of, 646
diagnosis of, 679
from achylia gastrica, 685
from chronic constipation, 685
from foreign bodies, 685
Stomach, cancer of, diagnosis of, from gall-bladder disease, 681
from gastric granuloma, 685
from grave anemias, 681
from lues, 685
from tuberculosis, 685
from tumors of kidney, 685
of large intestine, 685
of omentum, 685
enteritis in, 686
fibrous, 662
fistula in, 686
gastric acidity in, 672
tests for, 673
contents in, microscopic examination of, 674
syphilis and, 661
ulcer and, 661
gastroscopy in, 679
gelatinous, 662
habits and, 660
hemorrhage in, 669
heredity and, 659
"hour-glass" in, 686
hygiene and, 661
incidence of, 659
jaundice in, 686
location of, 663
malaria and, 661
medullary, 662
metastases in, 665
morbid anatomy of, 661
mucoid, 662
nature of, 646
obstruction at cardia in, 685
occupation and, 660
operations for, contra-indications to, 709
exploratory incision in, 709
gastrectomy, 710, 711, 718
gastro-enterostomy, 709
gastro-esophagostomy, 710, 719
gastrostomy, 711
indications to, 709
jejunostomy, 711
pylorectomy, 711
perforation in, 686
pyloric obstruction in, 685
race and, 659
rheumatism and, 661
roentgen examination in, 677
scirrhus, 662
secondary, 664
sex and, 659
signs of, 665
social status and, 660
symptoms of, 665
clinical grouping of, 667
test-meal in, 672
thrombosis in, 686
trauma and, 660
treatment of, 708
tuberculosis and, 661
ulcerating, 662

Stomach, cancer of, vomiting in, 670
carcinoma of, 658. *See* Stomach, cancer of.
cirrhosis of, 707
congenital anomalies of, 599, 704
enlargement of, 603
faulty position of, 603
contour of, fluoroscopic observation of, 594
contracted, 600
prognosis of, 600
symptoms of, 600
contraction of, 703
cysts of, 724
dilatation of, acute, 727
etiology of, 728
treatment of, 728
dilated "splashy," in gastric ulcer, 623
in ulcer of duodenum, 695
diseases of, abdominal examination in, preparation of patient for, 567
tenderness and, 571
age and, 560
appetite and, 566
auscultation in, 574
"combined" acidity and, 580
constipation and, 566
diagnosis of, 559
diarrhea and, 567
esophagoscopy and, 574
examination of feces in, 589
fluoroscopic examination in, 593
"free hydrochloric acidicy and, 580
gastric acidity and, 579
emptying power and, 575
retarded, 578
extracts and, macroscopic appearances of removed, 576
amount, 577
bile coloring, 576
chymification, 578
color, 576
mucus, 577
odor, 577
microörganisms in, diagnostic significance of, 587
microscopic estimation of, 585
organic acids in, 583
specific ferments in, 583
edestin test of Fuld and Levison for, 583
glycyltryptophan test for, 585
peptic index for, 584
tryptophan test for, 585
Stomach, disease of, gastric extracts and, Wolff-Junghans' test for soluble albumin in, 585
malfunction and, 561
gastroscopy and, 574
hemorrhage and, 565
infectious diseases and, 560
inspection in, 568
lactic acid and, 580
metastases and, 572
nausea and, 564
"occult" blood and, 580
operative procedures and, 561
pain and, 562
palpation in, 570
percussion in, 573
physical examination in, 567
rectal examination in, 572
roentgen examination in, 592
sex and, 560
"total" acidity and, 580
volatile fatty acids and, 580
vomiting and, 564
weight and, 566
diverticula of, 704
enlargement of, in ulcer of duodenum, 701
examination of, by roentgen plates or films, 598
foreign bodies in, 706
diagnosis of, from cancer, 685
treatment of, 706
hemorrhage of, 612, 724. *See* Gastric hemorrhage.
in gastric ulcer, 632
in pyloric stenosis, 635
treatment of, 724
hour-glass, 726
in cancer, 686
in gastric ulcer, 631
hypertrophy of, 703
injuries of, 705
lymphatics of, gastrectomy and, 711
mobility of, 597
myxomata of, 707
obstruction of, 725
treatment of, 725
operations in, 729
gastrectomy, 745
gastroduodenostomy, 751
gastro-enterostomy, 751
anterior, 752
posterior, 754
gastrojejunostomy, 752
gastropexy, 742
gastroplication, 742
gastrostomy, 729
gastrotomy, 729
incision in, 729
pylorodiosis, 748
pyloroplasty, 748
papillomata of, 707
perforations of, in gastric ulcer, 623

Stomach, pyloric stenosis of, benign, 633. *See* Pyloric stenosis.
in infancy, 600. *See* Pyloric stenosis in infancy.
rupture of, 705
sarcoma of, 708
spasms of, diagnosis of, 596
"splash," in pyloric stenosis, 637
syphilis of, 649, 706
age and, 649
blood in, 655
cancer and, 661
etiology of, 649
gastric acidity in, 655
extracts in, 655
malfunction in, 651
incidence of, 649
laboratory examination in, 655
luetic lesion in, 651
pathology of, 649
sex and, 649
stool in, 655
test-meals in, 655
treatment of, 706
Wassermann-Noguchi reactions in, 651
x-ray examination in, 657
tuberculosis of, 658, 707
cancer and, 661
diagnosis of, 658
from cancer, 685
tumors of, 707
ulcer of, 616. *See* Gastric ulcer.
variations in, 703
volvulus of, 704
wounds of, 706
prognosis of, 706
treatment of, 706
Stool in gastric ulcer, 625
in syphilis of stomach, 665
Strauss treatment of congenital hypertrophic pyloric stenosis, 785
Streptococcic infection in wounds of chest, 324
Stricture of esophagus, 48
Subacute posterior suppurative mediastinitis, 46
Subcutaneous emphysema, 240
rupture of spleen, 509
Subpleural connective tissue, abscess of, 249
emphysema, 240
Suffocative compression of thorax, 221
Suppurations of lungs, 273
Suppurative mediastinitis, subacute posterior, 46
pancreatitis, primary, 448
secondary, 452
Surgical pneumothorax, 232
Syphilis of breast, 153
diagnosis of, from acute pancreatitis, 456
from splenic anemia, 525
of liver, 364
of pancreas, 493
of stomach, 649, 706
Syphilis of stomach, age and, 649
blood in, 655
cancer and, 661
etiology of, 649
gastric acidity in, 655
extract in, 655
malfunction in, 651
incidence of, 649
laboratory examination in, 655
luetic lesion in, 651
pathology of, 649
sex and, 649
stool in, 655
test-meals in, 655
treatment of, 706
Wassermann-Noguchi reactions in, 651
x-ray examination in, 657
Syphilitic ulcers of esophagus, 47

T

Talma operation, 801
Teratoma of omentum, 796
Test-meal in cancer of stomach, 672
in gastric ulcer, 624
in pyloric stenosis, 637
in syphilis of stomach, 655
in ulcer of duodenum, 695
Thoracico-abdominal wounds, 235
Thoracoplasty, extrapleural, in treatment of pulmonary tuberculosis, 299
Thoracostomy for foreign bodies in lung, 278
precardial, 352
with rib resection for empyema, 263
Thorax, actinomycosis of, 249
commotion of, 221
treatment of, 221
compression of, suffocative, 221
prognosis of, 223
symptoms of, 223
treatment of, 223
congenital, treatment of, chondrotomy in, 291
contraction of, 204
contusions of, 220
prognosis of, 221
symptoms of, 221
treatment of, 221
cysts of, 251
echinococcus, 251
deformities of, disease of vertebræ and, 202
dilated, treatment of, chondrotomy in, 291
injuries of, 220
paralyticus, 203
resection of, for empyema, 271
rigid, treatment of, chondrotomy in, 291
rigidity of, congenital, 202
superior aperture of narrowing of, 202
surgical diseases of, 240

Thorax, traumatic hemorrhage from, 236
tumors of, 251
benign, 253
wounds of, non-penetrating, 230
Thrombosis in cancer of stomach, 686
Tiegel's overpressure apparatus in intrathoracic surgery, 215
thoracic flexible metal drain, 103, 105
Torek's incision in thoracic operations for carcinoma of esophagus, 94
Torsion of omentum, 797
"Total" acidity in diagnosis of diseases of stomach, 580
Transfusion of blood in pernicious anemia, 542
in wounds of chest, 324
Transgastric resection for gastric ulcers, 747
Transpleural esophagogastrostomy in treatment of spastic stenosis of esophagus, 59
Transthoracic operation for carcinoma of esophagus, 89
after-treatment in, 103
closure of thoracic wound in, 100, 102
exposure of tumor in, 95
extraction of stump and tumor together, 100
incision in, 93
instruments for, 91
posture of patient in, 91
of surgeon in, 93
preparation for operation, 90
of patient, 89
resection of, tumor in, 98
technic of, 89
Traumatic aneurysm, fractures of ribs and, 226
empyema, 259
hemorrhage from thorax, 236
hernia of lung, 282
pneumothorax, 230
Trephining of rib for empyema, 267
Tryptophan test for specific ferments in gastric extracts, 585
Tuberculosis of breast, 154
of liver, 367
of pancreas, 493
pulmonary, surgery of. *See* Pulmonary tuberculosis.
retroperitoneal, diagnosis of, from cysts of pancreas, 486
of ribs, 248
of spleen, 518
of stomach, 658, 707
cancer and, 661
diagnosis of, 658
from cancer, 685
Tuberculous empyema, 260
Tuberculous ulcers of esophagus, 47
Tuffier's operation for pulmonary tuberculosis, 298
Tumor, abdominal, in cancer of stomach, 671
in pyloric stenosis in infancy, 602
in congenital hypertrophic pyloric stenosis, 779
Tumors of breast, 163
of chest-wall, 253
of kidney, diagnosis of, from cancer of stomach, 685
from cysts of pancreas, 486
of large intestine, diagnosis of, from cancer of stomach, 685
of liver, 377
diagnosis of, from cysts of pancreas, 485
of lungs, malignant, 255
of male breast, 197
of mediastinum, posterior, compression stenosis of esophagus and, 61
of nipple, 145
of omentum, 793
of pancreas, 493
of pericardium, 352
of peritoneum, diagnosis of, from cysts of pancreas, 486
of pleura, malignant, 254
of spleen, 513
of stomach, 707
of thorax, 251
benign, 253
malignant, 253
of vertebral column, diagnosis of, from cysts of pancreas, 486
Typhoid osteochondritis, 247
osteoperiostitis, 247
diagnosis of, 248
treatment of, 248

U

Ulcer of duodenum, 686, 763
abdominal tenderness in, 695
acute, 691
pancreatitis and, 447
perforating, 771
age and, 687
anemia in, 690, 694
appetite in, 694
belching of sour gas in, 693
calloused, 691
chronic, 691
constipation in, 694
cutaneous burns and, 764
diagnosis of, 764
dilated "splashy" stomach in, 695
enlargement of stomach in, 701
eructations in, 693
"food-ease" of pain in, 692
habits and, 689
hematemesis in, 693

Ulcer of duodenum, hemorrhage in, 691
incidence of, 686
laboratory examination in, 695
malignant change in, 644
melena in, 693
morbid anatomy of, 689
"occult" hemorrhage in, 693
pain in, 692, 763
pain-time in, 692
perforation in, 690, 691
previous disease and, 687
pyrosis in, 693
roentgen evidence in, 697
secondary effects of, 690
sex and, 687
signs of, 694
stenosis of duodenum in, 690
stool in, 697
symptoms of, 691, 763
test-meal in, 695
total acidity in, 696
treatment of, 764
vomiting in, 693, 763
"water-brash" in, 693
weakness in, 694
esophagus, 46
dysphagia in, 47
pain in, 47
peptic, 47
syphilitic, 47
treatment of, 47
tuberculous, 47
gastric, 616
abdominal tenderness in, 622
acidity of gastric extracts in, 625
adhesions in, 632
age and, 616
appetite in, 621
blood in, 624
cancer of stomach and, 640, 661
complications of, 637
constipation in, 621
course of, 640
diarrhea in, 621
dilated "splashy stomach" in, 623
eructations in, 621
etiology of, 616
excision of, 746
actual cautery in, 747
Rodman's operation for, 747
transgastric resection for, 747
foci of infection in, 624
frequency of transition of, to cancer, 646
gastro-enterostomy as protection against malignant transition of, 645
habits and, 617
headache in, 622
hemorrhage in, 620, 632
subjective evidences of, 621
Ulcer, gastric, hour-glass contraction in, 631
infectious diseases and, 617
laboratory examination in, 624
location of, 617
malaise in, 622
malignant change in, 642
metamorphosis in, 631
melena in, 621
morbid anatomy of, 617
nationality and, 616
nature of, 640
nutrition in, 622
occupation and, 616
pain in, 618
perforation in, 632
peristalsis in, 623
physical examination in, 622
pyloric obstruction in, 631
pyrosis in, 621
sex and, 616
signs of, 622
stools in, 625
symptoms of, 618
symptom-complex of, clinical variations in, 644
test-meal in, 624
vomiting in, 620
weakness in, 622
x-ray examination in, 626
peptic, gastro-enterostomy and, 760
Ulcerating cancer of stomach, 662
Urine in chronic pancreatitis, 472
in congenital hypertrophic pyloric stenosis, 779
in pyloric stenosis in infancy, 601
Urobilinuria in hemolytic jaundice, 537

V

Vagolysis combined with esophagoplication in treatment of spastic stenosis of esophagus, 56
Valvulotomy, external, 337
Verneuil-Kümmel's disease, 202
Vertebræ, diseases of, deformities of thorax and, 202
Vertebral column, tumors of, diagnosis of, from cysts of pancreas, 486
Villous papilloma of breast, 169
Visceral pleurectomy, 272
Volatile fatty acids, diagnosis of diseases of stomach and, 580
Volvulus, 808
of stomach, 704
Vomiting in acute pancreatitis, 448, 453
in cancer of stomach, 670
in chronic pancreatitis, 469
in congenital hypertrophic pyloric stenosis, 778
diagnosis of diseases of stomach and, 564
in gastric ulcer, 620
in gastroptosis, 608
in ileus, 820

Vomiting in pancreatitis calculi, 489
in pyloric stenosis, 634
in rupture of pancreas, 440
in ulcer of duodenum, 693, 763
in wandering spleen, 512

W

Wandering spleen, 511
diagnosis of, 513
etiology of, 511
nausea in, 512
pain in, 512
pathology of, 512
symptoms of, 512
treatment of, 513
vomiting in, 512
Wassermann-Noguchi reactions in syphilis of stomach, 651
"Water-brash" in gastric ulcer, 621
in pyloric stenosis, 635
in ulcer of duodenum, 693
Weight, diagnosis of diseases of stomach and, 566
Wilm's operation of columnar resection of ribs to narrow thorax in pulmonary tuberculosis, 307
Wirsung, duct of, relation of, to common bile duct, 432
Witzel's gastrostomy, 736
Wolff-Junghans' test for soluble albumin in gastric extracts, 585
Wounds of breast, 143
of chest, 313
penetrating, 315
operations for, 319, 325
x-ray in, 316
superficial, 314
of diaphragm, 326
of esophagus, 43
of gall-bladder, 391
of heart, 339
of liver, gunshot, 363
shell, 363
Wounds of liver, treatment of, 364
of pancreas, 439
gunshot, 439
penetrating, 439
treatment of, 439
of pericardium, 340
of spleen, penetrating, 509
of stomach, 705
thoracico-abdominal, 235
of thorax, non-penetrating, 230

X

X-rays in carcinoma of breast, 186
in diagnosis of abscess of liver, 375
of bronchiectasis, 286
of cirrhosis of stomach, 707
of cysts of pancreas, 484
of gall-stones, 404
of pancreatic calculi, 490
of penetrating wounds of chest, 316
of pulmonary abscess, 274
of tuberculosis of ribs, 248
examination in cancer of stomach, 679
of esophagus, 36
in gastric ulcer, 626
in gastroptosis, 609
in pyloric stenosis, 638
in syphilis of stomach, 657

Y

Yankauer's electric suction apparatus, 35

Z

Zürich cabinet, intrathoracic surgery and, 212

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